THE

PSYCHOLOGY OF TIME

HISTORICALLY AND PHILOSOPHICALLY CONSIDERED
WITH EXTENDED EXPERIMENTS

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PREFACE.

The present monograph, reprinted from the AMERICAN JOURNAL OF PSYCHOLOGY, Vol. III, No. 4 and Vol. IV, No. 1, comprises work done at Clark University in the year 1889–90. In presenting the same in its new form, I take the opportunity of expressing very gratefully my indebtedness to valuable advice and suggestions continually extended to me by President G. Stanley Hall, in whose Department of Psychology the work was undertaken, by Dr. Edmund C. Sanford, Instructor in Psychology, and by Dr. Warren P. Lombard, Assistant Professor in Physiology. Also to the many others who have submitted themselves to tedious and time-robbing experimentation, I wish here to make the poor return of my thankful appreciation.

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I.—Historical.

In the history of language, words for 'time' are long preceded by words for 'past,' 'present,' and 'future,' and in myth and philosophy, Time makes a late appearance. The early Greek philosophers, even Parmenides and Heraclitus, naïvely took it for granted. Yet in this period questions were discussed that involved time; it is certain that the speculation of Pythagoras regarding number, descended with direct formative influence upon Aristotle's philosophy of time, and problems like Zeno's of Achilles and the tortoise, turned attention critically toward time.

All of previous philosophy is said to be summed up in Plato. I have discovered nothing more indicative of the status of time philosophy in Plato than the following found under 'time' in Day's "Analytical Index" of Plato's Dialogues (London, 1870.) "Time is the image of eternity (Tr. ii, 341, 342; Tim. 37 D, E; 38 A, B, C, D, E; Tr. vi, 155; Tim. 97 C);[1] belongs wholly to generation (Tr. ii, 338; Tim. 35, B, C; 36, A); is measured by the movements of heavenly bodies (see references above); time to depart and die (Tr. 129; Apol. 42, A); time is short compared with eternity (Tr. ii, 298, 186; Rep. 608, C; 498, D; see references in Stallbaum); time is nothing, and is not deserving of the solicitude of an immortal being (Tr. 298; 608, C); time and tune synonymous with good education (Tr. ii, 96; Rep. 413, D)." Time, *per se*, is nowhere psychologically contemplated by Plato; his nearest approach is in the Timæus as above. Time is not one of his five categories given in the Sophist, (being, rest, motion, sameness, difference). He conceived that motion was given to things because necessary to change; to the Kosmos alone was given rotation in a fixed circle, this being

[1] "Tr." refers to translation in Bohn's Classical Library; numbers and capital letters refer to the register of Ast and Stallbaum.

"the movement most in harmony with reason." With the rotation of the Kosmos began the course of Time — years, months, days, etc. Anterior to the Kosmos, there was no time, no past, present and future; no numerable or measurable motion or change. The ideas being without fluctuation or change, existing *sub specie æternitatis*, had only a perpetual present, no past or future; along with them subsisted only the disorderly, immeasurable movements of Chaos. The nearest approach which the Demiurgus could make in copying these ideas, was by assigning to the Kosmos an eternal and unchanging motion, marked and measured by the varying positions of the heavenly bodies. For this purpose the sun, moon, and planets were distributed among the various portions of the Circle of the Different, while the fixed stars were placed in the Circle of the Same, or the outer circle, revolving in one uniform rotation, and in unaltered position in regard to each other. The interval of one day was marked by one revolution of this outer or most rational circle, etc. . . . The phenomena of vision and hearing are included among the works of reason, because the final cause of these higher senses is to give men perceptions of number through contemplation of the measures of time. . . . An eternal sameness or duration, without succession, change, generation or destruction, this passes into perpetual succession or change, with frequent generation and destruction, into time.[1] This is the most specific conception previous to Aristotle, but it is really the naïve idea of time interwoven with Plato's doctrines of creation. In later philosophers the problems of time and memory are closely involved, but for Plato the latter is only "the power which the soul has of recovering, when by itself, some feeling which it experienced when in company with the body." His illustration is that of impressions left in wax.[2]

ARISTOTLE was the first to ask *how* we perceive time.[3] He did not conceive his Kosmos to have had a beginning; all in it is an eternally changing correlation between matter

[1] "Plato and other companions of Sokrates" by George Grote, (London, 1865) III, 248—257, and notes.
[2] Phædo, 73, 74.
[3] Alfred Wm. Benn, "The Greek Philosophers," I, 326. Wilhelm Volkmann, "Lehrbuch der Psych.," I, 37. Edwin Wallace, "Aristotle's Psych.," introduction. Also Grote, Lewes, etc.

and form.[1] "Matter is the original substratum, while form is nothing apart from form."[2] There are all gradations of this correlation, from clay bank to statue, from statue to human soul.[3] Soul ranks with form, not with matter. The matter to which soul stands correlated, is a natural body (*i. e.*, a body having within it an inherent principle of motion and rest) organized in a certain way, or fitted out with certain capacities and preparations to which soul is the active and indispensable complement.[4] The soul is dependent on the body for all its acts and manifestations, and brings to consummation what in the body exists as potential only.[5] . . . We do not say the soul weaves or builds;[6] we say that the animated subject, the aggregate of soul and body, *the man*, weaves or builds. So we ought also to say, not that the soul feels anger, pity, love, hatred, etc., but that the man with his soul does these things. . . . This is true, not only in regard to our passions, emotions, and appetites, but also in regard to our perceptions, phantasms, reminiscences, reasonings, efforts of attention, etc. . . . The actual movement throughout these processes is not in the soul, but in the body . . . They are at once corporal and psychical. . . . Soul is the movent, inasmuch as it *determines* the local displacement, as well as all the active functions of the body—nutrition, growth, generation, sensation, etc.[7] . . . Soul in all its varieties proceeds from the Celestial Body or abode of Divinity.[8] . . . The varieties of soul are distributed into successive stages. . . . The lowest soul is the primary cause of digestion and nutrition; it is cognate with celestial heat.[9] . . . We advance upward now from the nutritive soul to that higher soul, which is at once nutritive and sentient . . . with multiple faculties and functions. . . . Sensible perception with its accompaniments, forms the char-

[1] De Celo, Bk. II, Ch. 1 (Ed. Sprengel); Wallace, op. cit., p. xii.
[2] Metaph. Z, 8, 1033, b. 12 seq.; Θ. 3, 1047 a. 25.
[3] De Anima, II, 2, 414; Physica, II, 2, 194, C 8; Metaph. H 6, 1045, C 18; De Gener. Aninal. II, 1, 735 a 9; De Celo, IV, 3, 310, C 14.
[4] De Anima, II, 1 sq.
[5] De Generat. Animal. II, i, p. 731, b. 29.
[6] De Anima I, iv, p. 408, b. 12.
[7] De Anima II, iv, p. 415, b. 1.
[8] See Grote, Ibid. 220.
[9] De Anima II, i, p. 731, b. 33.

is that which gives thereto definite individual being. Matter acteristic privilege of the animal[1] . . . and admits of many diversities from the simplest and rudest tactile sensations . . . to the full five senses.[2] . . . The sentient faculty, even in its latest stage, indicates a remarkable exaltation of the soul in its character of form. . . . The soul, *qua* sentient and percipient, receives the form of the *perception*[3] . . . as wax from a signet.[4] . . . The sentient soul (its 2d stage) requires a cause to stimulate it into actual seeing or hearing, . . . a stimulus from without, from some individual object, tangible, visible or audible; but the noëtic or cognizant soul (3d stage) is put into action by the abstract and universal . . . so that a man can at any time meditate on what he pleases[5] . . . All the objects generating sensible perception are magnitudes.[6]

Some perceptions are peculiar to one sense alone, as color to the eye, etc. There are some perceivables not peculiar to any one sense alone, but appreciable by two or more . . . such are motion, rest, number, figure, magnitude.[7] "But each single sense perceives nothing but one single quality or group of qualities.[8] . . . There is required then some one function of the mind, by means of which it gains perceptions of all objects,[9] . . . some common central organ of perception in which the separate communications of the senses are combined; . . . it must within one and the same moment of time, present before itself two or more reports of sense."[10] . . . This exercise of comparison, which Aristotle thus assigns to the central or the common sense, is not, however, restricted to the work of distinguishing the separate communications of the senses; it displays further its synthetic power in grasping the common properties which are involved in the

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[1] De Sensu., i, p. 436, b. 12.
[2] De Anima II, iii, p. 414, b. 2; 415 a. 3; III, i, p. 424, b. 22; xiii, p. 435, b. 15.
[3] Ibid. II, xii, p. 424, a. 32, b. 4.
[4] Ibid. II, xii, p. 424, a. 19.
[5] Ibid. II, v, p. 417, b. 22; III, iii, p. 427, b. 18.
[6] De Sensu., vii, p. 449, a. 20.
[7] Grote's Aristotle II, 186-198; De S. et S. i, p. 437, a. 8; iv, p. 442, p. 4–12.
[8] Psychology iii, 7, p. 431, a. 24.
[9] De S. et S. 7. p. 449, a. 8.
[10] Psy., p. 426, b. 22.

existence of the qualities of the body.[1] For at the same time as we perceive, say color, we perceive it, further, as a colored surface or *magnitude*; at the same time as we have the sensation of notes following on one another, we perceive the fact of *number*; and at the same time again, as we feel a surface hard or soft, we perceive it as some kind of *figure*. Beyond these, the particular objects of the single senses, we require to recognize a number of qualities ("categories") which enter more or less into each of our sensations . . . and which, in Aristotle's words, "we perceive immediately in connection with each perception."[2] Chief of these qualities or "categories" were "*motion*" and "*rest*;" next came "*number*." Finally, for our purpose, Aristotle remarks: "*Time is the number of motion*."[3] Psychologically considered, then, time *is an immediate* (*central*) *sense-perception of* "*the number of motion*."

But is not memory requisite for perception of time? We are told "Memory, as well as phantasy (imagination) are continuations, remnants, traces or secondary consequences of the primary movements of sense. Both of them belong to the same psychological department—to the central sentient principle, and not to the cogitant or intelligent *nous*."[4] "In acts of remembrance we have a conception of past time, and we recognize what is now present to our mind, as a copy of what has been formerly present to us either as perception of sense or as actual cognition[5]; while in phantasms there is no conception of past time, nor any similar recognition, nor any necessary reference to our past mental states." "What is remembered is a present phantasm assimilated to an impression of the past."[6] Aristotle draws a marked distinction between the (memorial) retentive and reviving functions, *when working unconsciously and instinctively*, and the same two functions when stimulated and guided by a deliberate purpose of our

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[1] De Anima III, i, p. 425, a. 15.
[2] De S. et S., C. 4, p. 442, b. 4; De A. II, 6, p. 418, a. 17. Wallace's Aristotle, Psych., lxxvi–lxxix.
[3] De Celo, Ch. 9, 8–10.
[4] De Memor. et. Remin. i, p. 451, a. 5; p. 449, a. 10.
[5] Ibid. i, p. 449, b. 22.
[6] Ibid., p. 450, a. 30; 451, a. 15; De Memor., p. 240.

own, which last he calls reminiscence. He considers memory as a movement proceeding from the centre (heart) and organs of sense to the soul, and stamping an impression thereupon; while reminiscence is a counter-movement proceeding from the soul to the organs of sense."[1-2-3]

On occasion, however, he used time both to denote an objective and a subjective concept. "Both motion and time are thus eternal, both are also continuous; *for either the two are identical*, or time is an affection (πάθος) of motion."[4]

Thus in brief, time-perception with Aristotle was a direct sense-perception — the immediate function of the sentient faculty or soul; this, whether under the presentation of primary sensation or of memory. We have given much space to this remarkable first exposition of time because it is most important historically, and in its essential features it has survived in all ages, and is even now the accepted theory of prominent psychologists.

Post-Aristotelian and Mediæval discussions of "the faculties" are important, in so far as they lead to later theories. The doctrine of soul faculties is so old that Diogenes Laertius cites Pythagoras as its source. After Aristotle, the Stoics found difficulty in agreeing upon the number of the faculties, and in reconciling any plurality of them with the unity of the soul. To these perplexities the Neo-Platonists joined that of the self-consciousness of the soul. Philo compared the relation of the soul to the faculties to that of the house to its tenants. The Patristic authorities insisted on the strict unity of the soul. Tertullian substituted the term "soul-faculties" for the older term "soul parts" or "soul divisions," and compared the soul to the wind which blows the pipes of an organ; the pipes representing the faculties. Gregory of Nazianz revived the simile of Plato, that the

[1] De Anima I, iv, p. 408, b. 17; De Memor. i, p. 450, a. 30; ii, p. 453, a. 10.

[2] Grote. op. ct. II, 212–215.

[3] Memory "is the permanent possession of a sensuous picture, as a copy which represents the object of which it is the picture." De Memor. I, p. 451, a. 15. He adds that memory is the function of our ultimate faculty of sense which "is also that by which we gain a consciousness of time." Ibid., p. 450, a. 12.

[4] Metaph. Λ, p. 1071, b. 15.

soul was the driver of the wagon; and the faculties were the horses. St. Augustine developed advanced ideas of memory, but with the revival of Aristotle among the Scholastics, "the faculties" again rose almost to supreme discussion; all deemed themselves bound to maintain the unity of the soul. The view of Thomas Aquinas was that most commonly held, *i. e.*, "the faculties, from the essence of the soul, *sicut a principio fluunt.*"[1] Roger Bacon contended for the *sensus communis* of Aristotle, whose philosophy in general he accepted.[2] With Wm. of Occam, all thoughts are "conditions of the soul."[3] During the Reformation, the orthodox doctrine was defended by Suarez, while Melanchthon held nearly to the teachings of Aristotle. Thus the opposing views of "unity" vs. "faculties" occupied the field, at the date of Descartes, Hobbes, and Leibnitz.

RENÈ DESCARTES followed the orthodox schoolmen as against Aristotle in considering the soul as one indivisible "thinking substance;" its diverse "faculties" are but different *modes* of the one "*facultas cognoscitiva*" — the "thinking soul."[4] Aristotle at least caught sight of the mystery of our perceiving at the single moment that *is*, the 'fore and aftness' of a series which *has past*, and he conceived apparatus and processes to account therefor. Descartes, with naïveté, looked on such mental acts as direct and indissoluble "modes," or "conditions," of the "thinking soul."[5] In this conception is the foundation of his philosophy; the soul sees directly; ideas are intuitions, "the innate power of thought itself;" "they are in the mind, and when exercised, are perceived to have been there before."[6] Certain of these innate concepts lie at the foundation of all the rest; without them no

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[1] For full references for above see Volkmann's Psychologie (1885), I, 22, sq.
[2] Erdmann's Hist. Philos., I, 478-481.
[3] Ibid., 504.
[4] Pass. de l'âme I, 47 sq.; Med. end of II, IV; VI, 77, etc.; Prin. d. Philos. I, LIII; Kuno Fischer—Descartes and his School—Tr. Gordy, p. 419.
[5] Letter to Vatier, Nov. 17th, 1643; Ed. Elz. 1, Ep. 116; Ibid., Ep. 105; Princ. i, § 57-59; Med. III.
[6] Règ. iii, p. 211-214; V, 225; Med. V, 64; Erdmann's Hist. Philos., Hough, Tr. II, 26.

kind of conception of anything is possible. *Space and time are such direct, innate, and fundamental concepts.*

Descartes makes one advance upon Aristotle, in specially distinguishing duration from the "numbering of motion." "We shall also have most distinct conceptions of duration, order, and number, if in place of mixing up with our notions of them, that which properly belongs to the concept of substance, we merely think that the duration of a thing is a mode under which we conceive this thing in so far as it continues to exist;"[1] "for we do not indeed conceive the duration of things that are moved, to be different from the duration of things that are not moved."[2]

Descartes distinguished two kinds of thought—"active" and "passive;" the active are the "different modes of willing;" the "passive" include time-perceptions. Yet time was not with Descartes a *sense* perception as with Aristotle; *his time-perceptions spring innately "from the intellect" or soul "alone."*[3]

Yet Descartes' physiology is not always easily harmonized with his philosophy, nor his mechanical explanations of memory with *entirely* innate intuitions of time. He says "Recollections are traces of images on the brain" — "traces of previous movements left in the brain like folds in paper;" the movements of the vital spirits through these traces "become for the soul, occasion and opportunity for calling forth ideas which resemble them."[4] "By memory, we connect present and past." "When I think of myself as now existing, and recollect besides that I existed some time ago, and when I am conscious of various thoughts, whose number I know, I then acquire the ideas of duration and number, which I can afterwards transfer to as many objects as I please."[5] Descartes tells us "the movements of the brain affect the soul or mind."[6] "Perception is impossible without

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[1] Prin. d. Phil., I, LV, 137.
[2] Ibid., I, LVII, (Tr. Ed. Edinburgh, 1873.)
[3] Ibid., I, XXXII; Med., II, etc.
[4] Notæ ad. progr. quodd., p. 185–188; Erdmann op. ct. II, 28.
[5] Med. VI, 88; III, 45.
[6] Prin. d. Philo. I, XLVIII, 170.

the body."[1] "From the motion of the body alone, can the various sensations be excited."[2] "The soul perceives only in so far as it is in the brain."[3] Yet he as distinctly says "by the omnipotence of God, the mind can exist without the body,"[4] and one of his commentators says "according to the fundamental principles of his philosophy, mind, on account of its absolute diversity from body, is supposed to hold no immediate converse with matter, but only to be cognizant of it by means of its own modifications, determined hyperphysically on occasion of certain affections of the body with which it is conjoined."[5] Kuno Fischer shows that it was these uncertainties or contradictions of Descartes, which led in opposing directions to the occasionalism of Geulinx, the systems of Malebranche, of Spinoza and of Leibnitz."

THOMAS HOBBES declared that the soul is known only through faith, and is not a subject of philosophy; he was the first to confine his speculations to "mental facts," avoiding cognative "faculties;" though he did at times "see the need of some other sense to take note of sense by," he yet presaged so much that is explanatory in the unfathomed *processes* of thought, as bravely to declare "that all that is wanted to account for such introspective consciousness could be found in memory."[6] He says all sense and all thought are "subjective;" are "something that lies entirely in us;" "yet is as mechanical as nature." "According to a universally valid law of nature, the affections of the sense organ, when the impression has ceased, must continue, and this echo of the impression is called memory, thought, or imagination. It is so inseparable from the sensation that it may be compared to a sixth sense accompanying the rest. . . . *Like water troubled, an organ of sense will remain in motion.* . . . *In that case the corresponding phantasm is called imagination; or memory, if regard is had to the fact of the lapse of time, which like distance in space, is found to render the phan-*

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[1] Med. II, 27.
[2] P. d. P. IV, CXCVII.
[3] Ibid. IV, CXCVI.
[4] Reply to the several objections—Prop. 14, (Tr. Edinburgh, 1873.)
[5] Ibid. Note, p. 200; where see several references.
[6] "Hobbes" by George Croom Robertson (1886), p. 124.

tasms of sense both less clear as wholes, and less distinct in parts."[1]

In his De Corpore, Hobbes devotes Chapter VII to space and time. "All body . . . exists with one constant attribute of extension mentally represented as space; and all its variable and varying aspects explicable in terms of motion, are mentally represented in time." Time is "a phantasm produced by body in motion;" it is "simply the idea of motion, or of moved body." Yet he adds that time "*stands rather for the fact of succession or before and after in motion.*"

As far as I know, the word "succession" or any exact equivalent, here enters the discussion for the first time. "The comparison or assimilation of sense impressions into time percepts gets little further attention from Hobbes, though he notes in one place its ground-form, the recognition of identical experiences had at different times."[2] Hobbes is the Father of the English School of Association.[3] His importance in the history of the problem of time rests on his being the first of moderns to plant himself on this doctrine, namely: "There is no conception in a man's mind that hath not at first totally or by parts, been begotten upon the organs of sense. The rest are derived from that original."[4]

With SPINOZA time was a mode of his all-embracing substance.

JOHN LOCKE believed in an immaterial soul that thinks.[5] Its faculties are not "separate agents," but "different ways" or "powers" of thinking; the first "power" is to perceive.[6] There are two sources of ideas: First, sensation, and, second, "perception of the operations of our mind within us," which he calls "reflection."[7] "Which operations, when the soul comes to reflect on and consider, do furnish the understanding with another set of ideas, which could not be had from things

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[1] Human Nature, C. 3. Also he speaks of memory as "decay of sense;" *i. e.*, fading.
[2] Robertson, op. ct. 127.
[3] Lewes Hist. Phil., p. 232; Sir Wm. Hamilton in "Reid's Works," p. 898.
[4] Leviathan, C. i. See Robertson, op. ct., p. 84.
[5] Essay Concerning Human Understanding; Bk. II, Ch. xxiii, Sec. 22.
[6] Ibid. vi, 2; ix, 1.
[7] i, 3 and 4.

without; and such are perception, thinking, doubting, believing, reasoning, knowing, willing, and all the different actings of our mind; which we, being conscious of and observing in ourselves, do from these receive into our understanding as distinct ideas as we do from bodies affecting our senses. This source of ideas every man has wholly in himself."[1] One of the fundamental acts or powers of mind is that of "*bringing two ideas, whether simple or complex, together, and setting them by one another so as to take a view of them at once . . . by which it gets all its ideas of relations.*"[2] He devotes more than one chapter to "*relations*," *which, I believe, though destined to an important place, are here, for the first time, brought onto the psychological field, as separate mental elements*—surely the mark of an epoch, good or bad. Locke tells us that relations "consist in the consideration and comparing one idea with another."[3] Had he been asked what "considering and comparing" were, he probably would have said, "the act of perceiving relations." He says "the ideas of relations are often clearer than the subjects related."[4] He devotes a good share of his work to proving, against Descartes, that ideas are never *innate*, yet it is fundamental with his own system that these "relations" are perceived *intuitively*. With simple relations, "the mind is at no pains of proving or examining, but perceives the truth, as the eye doth light, only by being directed toward it. Thus the mind perceives that white is not black; that a circle is not a triangle; that three are more than two, etc."[5] "In every step reason makes . . . there is (and must be) an intuitive knowledge."[6]

Locke classifies time-perception as partly sensation and partly reflection. He sums up his chapter on our subject with six propositions: "(1) By observing what passes in our minds, how our ideas there in train, constantly some vanish and others begin to appear, we come by the idea of succession.

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[1] i, 3 and 4.
[2] xii, 1.
[3] xii, 7.
[4] xxv, 8.
[5] IV, ii, 1.
[6] IV, ii, 7.

(2) By observing a distance in the parts of this succession, we get the idea of duration. (3) By sensation observing certain appearances, at certain regular and seeming equidistant periods, we get the ideas of certain lengths or measures of duration as minutes, hours, days, years, etc. (4) By being able to repeat these measures of time, or ideas of stated length of duration in our minds, as often as we will, we can come to imagine duration where nothing does really endure or exist; and thus we imagine to-morrow, next year, or seven years hence. (5) By being able to repeat ideas of any length of time, as of a minute, a year, an age, as often as we will in our thoughts, and adding them one to another, without ever coming to the end of such addition any nearer than we can come to the end of number, to which we can always add, we come by the idea of eternity, etc. . . . (6) By considering any part of infinite duration, as set out by periodical measures, we come by the idea of what we call time in general." He says "by reflection, we perceive directly and intuitively the time-relation between these ideas."[1] "Most of the denominations of things received from time are only relations."[2] . . . "When one fixes his thoughts intently on one thing . . . he lets slip out of his account a good part of that duration, and thinks that time short." He denies, as against Aristotle, that we get our idea of succession from motion.[3] If motions are too slow, he says, we do not perceive their succession; if too fast, neither their duration or succession. The following presages psycho-physics: "Our train of ideas, when awake, probably succeed one another, in our mind at certain distances, not much unlike the images of a lantern turned round by the heat of the candle. This appearance of theirs in train, though perhaps it be sometimes faster and sometimes slower, yet I guess varies not very much in a waking man; *so has a certain degree of quickness*, with bounds beyond which it can neither delay or hasten. . . . *So that* to me it seems that the constant and regular succession of

[1] "Whenever the memory brings any idea into actual view, it is with a consciousness that it had been there before, and was not wholly a stranger to the mind." I, iv, 20.
[2] II, xxvi, 3.
[3] II, xiv, 6.

ideas in a waking man is, as it were, the measure and standard of all other successions."[1] He says "no two parts of duration can be certainly known to be equal." . . . "Time is not the measure of motion," but space *and* time . . . "time is to duration what place is to expansion."[2] In a word, time with Locke was an intuitive perception of relation between successive durative ideas; his discussions show much advance in our subject.

LEIBNITZ conceived the universe to comprise an infinite number of individual soul-units or monads, without causal relations to each other; by pre-established harmony each monad developed within itself a psychic life, "mirroring" or corresponding to the world within a certain scope around it.[3] Faculties, he declared, "were but fictions." The soul did not think, feel and perceive; but thought, feeling, perception, *were* the soul itself under different forms of activity. Time was one of these forms.[4] All thoughts were innate; "the mind itself is innate;" "all soul life develops from within itself."[5] Time, therefore, is innate, and but a "phenomenon" of soul development.[6] Leibnitz can with more consistency than Descartes declare ideas to be innate, as in his system *each* of his monads mirrors every event in the entire universe. Each is *unconscious* of all below a certain stage; thus all sensations and ideas are in the mind from the beginning, but rise to consciousness only when apperceived.[7] Characteristically of his system, he says space and time "express possibilities;" "they are of the nature of eternal truths, which relate equally to the possible and to the existing;" they determine existence in some of its relations, and as such are logically prior to any given form of existence. "Time (not duration) exists only as events are occurring, and is the relation of their succession." Time is purely rela-

[1] II, xiv, 8–12.
[2] II, xv, 5.
[3] Monadologie, p. 709, sq.
[4] De phen. real. p. 444; à Bayle, p. 159.
[5] Prin. d. l. Nat., p. 714.
[6] Compare Noveaux Essais, LIV, ii, Ch. i; 1, IV, i; à. Bayle, p. 159; à. Clarke.
[7] à. Borguet, p. 720; à. Bayle, p. 187; Monadologie, p. 706; System Noveau, p. 127; Prin. d. l. Nat., p. 715; ad. Des Bosses, p. 740.

tive and ideal;[1] a relation, he says, cannot be in the thing which it relates; "can not have one leg in one object, and the other leg in the other." The relation exists alone in the mind; yet, if all objects and events were annihilated, time and space would still have their ideal existence in the intelligence of God as the eternal conditions of all phenomena. Leibnitz gives us few psychological details of time; he included all vaguely under his *Vorstellungskraft*. He was perhaps the first of moderns to emphasize some requirement for "joining the manifold in one."[2]

CHRISTIAN WOLFF clarified the ideas of Leibnitz with greater influence upon German psychology in general than on our particular subject.[3]

SIR ISAAC NEWTON[4] and SAMUEL CLARKE (the latter by controversies with Leibnitz[5]) focused to clearer definition the thought of their day regarding space and time.

GEORGE BERKELEY instituted one of the greatest epochs in psychology by first disclosing the complex make-up of seemingly elemental sensations, but gave attention to space rather than time. "When abstracted from the succession of ideas in our mind, I can form no idea of time at all; it is nothing."[6] He looked upon time perception as an act of reason rather than of sense. "Sense supplies images to memory; these become subjects for fancy to work upon. Reason considers and judges of the imaginations." "Number is no object of sense." "The mind so far forth as sensitive, knoweth nothing."[7] "There is that in us not given by sense, though it is only in a latent state." Yet with Berkeley ideas were not innate preconditions as with Descartes; all thoughts are the direct gift of God; for as processes and laws they fall directly from His will.[8]

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[1] Opera Philos., p. 682, 752.
[2] Ep. III, ad. Des Bosses, op. Phil., 438.
[3] His chief departure from Leibnitz is that he denied that *all* monads are perceptive.
[4] Newton thought the omnipresent existence of the Deity constituted space and time. Principia, Ch. 1.
[5] Complete Works, London, 1732–42.
[6] Prin. of Human Knowl., § 99.
[7] Ibid. XXV; Siris § 288, 305.
[8] See Campbell Frazer's Berkeley, Phila., 1881.

DAVID HUME was critical rather than constructive. From Aristotle, we have seen the requirement for some "faculty" to join the manifold of mind steadily forcing itself upon consideration. Hume stripped the problem of vagueness. After reducing mind to a succession of impressions, ideas, and relations, he declares at the end of his treatise: "All my hopes vanish when I come to explain the principles which unite our successive perceptions in our thought or consciousness. . . . In short, there are two principles which I can not render consistent, nor is it in my power to renounce either of them, viz., that *all our distinct perceptions are distinct experiences*, and that *the mind never perceives any real connection among distinct existences.* Did our perceptions either inhere in something simple or individual, or did the mind perceive some real connection among them, there would be no difficulty in the case."[1] Here is the essence of our time-problem set forth for the first time with isolated explicitness, if yet imperfectly. It is perhaps the clearest proof of Hume's greatness, that, seeing the difficulty, and not seeing the answer, he refrained from a "system."

Following Locke, Hume recognized "perceptions of relation" to be the "essence of cognition."[2] Perception of time-relations, thus became an act of reason—something more than sense. All reasoning "consists in nothing but comparison and discovery of the relations, either constant or inconstant, which objects bear to each other."[3] Yet all he can explain of relation is, "that quality by which two ideas are connected."[4]

With Hume, "the ideas of space and time are *copies of impressions perceived in a particular manner.* The idea of necessary connection is merely the reproduction of an impression which the mind *feels* compelled to conceive in a particular manner." Our idea of time "is derived from the succession of our perceptions of every kind."[5] "All impressions

[1] Works (ed. 1854), ii, 551; Hume says it will ever be impossible to decide as to the origin of impressions—p. 113.
[2] Ency. Brit.
[3] Ibid. i, 100.
[4] Ibid. i, 29.
[5] Ibid., p. 54. Hume thinks that the idea of duration is derived from succession of change. "We associate the continual successions of our mind with steadfast objects; this gives us the idea of their (the steadfast objects) duration; without this associate succession, they would not appear in time." pp. 90, 57.

and all ideas are received or *form part of a mental experience only when received in a certain order — the order of succession.*" Yet he distinctly declares that "*Time is not a particular impression* . . . it rises from the manner of the succession of the impressions, *yet without making one of the number.*" "Five notes, played on a flute, give us the impression and the idea of time, though time be not a sixth impression, which presents itself to the hearing or any other of the senses. Nor can the mind by revolving over a thousand times all its ideas of sensation, ever extract from them any new original idea, *unless nature has so framed its faculties*, that it *feels some new original impression* arise from such a contemplation. But here it only takes notice of the *manner* in which the different sounds make their appearance, and *that* (the manner) it may afterwards consider, without considering the particular sounds, but may conjoin it (the consideration of the manner) with any other objects. The ideas of some objects it certainly must have, nor is it possible without these ideas, ever to arive at any conception of time, which since it appears not as any primary distinct impression, *can plainly be nothing but different ideas, or impressions, or objects, disposed in a certain manner, that is, succeeding each other.*"[1] It is difficult to reconcile Hume's above "*ideas* of time *derived* from succession," with his declaration that it "*can plainly be nothing but different ideas* . . . *succeeding each other.*" He did not quite arrive at the great question whether the *idea* of time is "nothing but ideas succeeding each other," yet no one has more lucidly cleared his mind to what time-perceptions are not. He was hampered by traditions of "relations," and that all ideas must be "unit representations" and "individual pictures;" yet he continually struggled toward the thought that time-perception should be explained by succession alone. One strangely isolated declaration markedly indicates his genius and the drift of his mind from his traditions. He says in his chapter on Ancient Philosophy: "The imagination readily takes one idea from another . . . is carried from one part of it (the succession) by an easy transition . . . *This easy transition is the*

[1] Ibid., p. 56.

effect or rather the essence of relation."

HARTLEY first sought to carry back much of psychology to physiology,[1] yet conceived memory and time-perception to be fundamental acts of mind.

CONDILLAC, abandoning Locke, declared "all our knowledge and all our faculties to be derived from sensations."[2] A sensation, which "preserves its vivacity," becomes attention. "If a sensation acquire greater vivacity than the former, it will become in its turn attention. . . . Our capacity of sensation, therefore, is divided into the sensation we have had, and the sensation we now have; we perceive them both at once, but we perceive them differently; the one seems as past, the other as present. The name of *sensation* designates the impression actually made upon our senses (present); and it takes that of *memory* when it presents itself to us as a sensation which has formerly been felt (past). Memory is only the transformed sensation. When there is double attention (to present sensation and past memory) there is comparison; for to be attentive to two ideas, and to compare them, are the same thing. But we can not compare them without perceiving some difference or some resemblance between them; to perceive such relations is *to judge*. The acts of comparing and judging, therefore, are only attention; it is thus that sensation becomes successively, attention, comparison, judgment. . . . . Numbering, imagining, wondering, having abstract ideas, *having ideas of time* and number, knowing general and particular truths, are only different ways of attending;"[3] *i. e.*, are but different successive combinations of sensation.

Thus by Condillac, for the first time in history, is absolutely the whole of mind conceived to be but different successive combinations, derived from a like source and of essentially like nature; the insufficient praise, which is bestowed upon Condillac for this position, is indicative of even a present lack of appreciation of its pre-eminent truth and importance; a truth toward which all modern psychology seems gradually tending.

It is just to PETER BROWN, Bishop of Cork, to note that he

[1] See his Theory of Vibratiuncles.

[2] Traité d. Sensations, p. 1 sq. For condensed exposition see first chapters of his Logique.

[3] Ibid.

had, perhaps, previously arrived at a similar conception, though indefinitely. Condillac preserved his belief in the soul as an entity; his follower, DE TRACY, abandoned such, while CABANIS and HELVETIUS avoided the question. Cabanis, for the French, inaugurated the epoch of considering psychology as entirely dependent on physiology. That part of his work, which has most bearing upon the matter in hand, is his physiological differentiation of internal from external sense. HELVETIUS' views are practically those of Condillac[1]. FRANCESCO MARIA ZANNOTTI, an Italian disciple of Hartley, held developed conceptions of time-associations.[2]

IMMANUEL KANT took up the problems stated by Hume; these were the mysteries of Mental Veracity and of the Unity of Diversities. For the solution of these questions Kant started with traditional belief in the dualistic entities, souls and things-in-themselves.[3] His day had not outgrown the error of conceiving the soul or mind to be the direct, active, and sole *organ* of thought; according to this view, things are known and seen immediately; the bodily organism is looked upon as a mere spy-glass, or rather, is practically neglected altogether. To Kant's clear mind, the first essence of ultimate material entity was plainly, in the light of the discussions of his day, immunity from change;[4] inasmuch, therefore, as to him, there was nothing but souls and things, since change could not happen to things, there was no alternative, but that such must be an effect or characteristic of mind.[5] This, then, is the first fundamental thought of, and key to, Kant: *The cause of all change lies in the mind.* But mental change means mental diversity; and having started with the unity of the soul, Kant was compelled to look upon mental Unity of Diversity as an ultimately insoluble mystery. Now comes the supreme merit of Kant, in that he inserted a clear wedge of distinction between the *causative* and the *caused* within the mind. He saw that diversity was a characteristic of the product or content of mind, while unity was characteristic of the way this

[1] See his De l'Homme, Vol. I, c. iv; De l'Esprit, Ch. 1.
[2] Della forza attrativa delle Idei, (1747 (?) to 1790).
[3] Critique, 2d Ed.; Meiklejohn's Tr.; pp. 22, 45, 104, 167, etc.
[4] Ibid. 29, 136, etc.
[5] Ibid. 25, 29. To Kant our bodily organism was but more "things."

content was held or bound together within or by the soul; Close at hand follows Kant's great demerit and confusion. While he is clear and consistent throughout in distinguishing the diverse content from the unitary form, he is neither clear nor consistent anywhere, in distinguishing between unitary form as *cause*, and as some sort of conscious *result*—self-conscious, even though he might conceive that result to be, in delusive distinction from other mental content or result.

Time with Kant is an *à priori* form of mind (p. 22). But confusion and contradiction is betrayed in this phrase from the outset; does he mean mind as *cause?* or mind as *result*, as *content?* Surely a result, a content, never is *till* it is, therefore the term *à priori* is never in any way applicable to it; yet we shall find Kant continually speaking of time as an *à priori intuition*, and classifying intuitions as *content* of mind.

This confusion is vital to Kant's philosophy; to understand it we must discover its origin. It will be noted that he first investigates space, and most profoundly; then he places time on precisely the same basis as space, as a "form of thought." Now when we consider sight, and remember that Kant was little, if at all, familiar with post-Berkeleyan psychology which splits up space-perception into disparate elements, we easily discover how he became impressed with the apparent unity of the visual field, in contradistinction to its diverse objective content; here "nothing objective is added to the field, when two objects appear *beside* each other;" this apparent "besideness" is nothing added to the objects, or to their objectivity, or to the objectivity of the whole field; it is, so it appeared to Kant, something apart from objectivity, from sense; he called it an "intuition." These objects are not *thought* beside each other; they merely *are* in that mental aspect. In this way space, in the abstract, appeared to him something apart from objectivity; Kant identified besideness with space, the apparent unity of abstract space with the apparent unity of the visual field; he assumed that the ultimate cause of both lay in the unity of the soul. Conceiving both to be attributes of mind, in order to designate "the field" from its objects, and space from its make-up content, he

called the one "matter," the other "form." Falling in with the confusion of ages, in using mind indifferently as an equivalent both of soul and of consciousness—that is, as *cause* and as *result*, it was easy for him to fall into like confusion as to *forms* of mind, and as to space and time as such forms; and finally he accustomed himself to declare that space and time are *à priori intuitions*[1], though evidently he never intended to mean that intuitions as present mental *results* were *à priori*.

It remains to discover how he came to put time upon the same basis as space as an *à priori* form or intuition. This appears to have come about entirely through careless susceptibility to analogy. Having worked out his problem with reference to the above and below of spatial diversities, it was easy to conceive that the same formula explained the fore and aftness of temporal diversities; here was change, and again "nothing objective added," yet mental perspective and intuition of relation; once more, according to his fundamental proposition, all cause of change can alone lie in the mind (soul); here, then, is but another *à priori* form of mind, needing nor permitting further analysis. The crucial error of Kant lay in not perceiving that the "unity of diversity" problem, and the "unity of space" problem, were, at the same time, time problems. Take away the co-existence of the diversity and there is no unity of diversity—these same diversities could then succeed each other in as many individual minds, as well as in an individual mind; we are then compelled to investigate whether mere succession in an individual mind may be conceived to yield perceptions of time relations or not. Our present purpose is in no way critical; we only wish to make plain that Kant did hold that the simplest possible succession in our mind was accompanied necessarily with some sort of intuition of fore and aftness, and to show how he came to this belief. The latter I have sufficiently indicated; it remains to give clear evidence of the extent of his theory. Too frequently to be mistaken, he makes explicit his position as follows: "Time is a necessary representation lying at the foundation of all intuitions. With regard to phenomena in general, we can not think away time from them" (p. 28). "It is the subjective

[1] Chapter on Time, p. 28; p. 22, 30 § 7.

condition under which all our intuitions take place" (p. 30). "Time is the formal condition *à priori* of all phenomena whatsoever" (p. 30). "All phenomena in general, that is, all objects of the senses, [not things, but all their objective representations], are in time, and stand necessarily in relations of time" (p. 31). Hume's notes, therefore, according to Kant, carry with their occurrence some sort of intuition, or awareness of their succession, and of their time-relation. There is, we think, abundant evidence for this interpretation and none whatever against it. It is in harmony with his system of philosophy as a whole. His declarations of it are explicit and comparatively numberless. The genetic progress of his Critique shows how he arrived at this view. His whole future *à priori* handling of the categories and of the synthetic activities of the understanding conforms to and supports it. It is upon precisely this conception that Kant, from the first, makes his main and fundamental division of the mental faculties; drawing a sharp line between two chief faculties, the one passively receptive, the other active or spontaneous, he classifies intuitions entirely among the former; to the latter belong all acts of the understanding.[1] There can be no doubt that any such complicated act as memory, used in the English school sense of the term and involving recognition of *having been before*, etc., would have been classed other than as passive intuition; *i. e.*, than as he did classify time-intuition; yet excluding recognition or memory proper from reproduction, we have Kant's imagination; which, in so far as intuition of sequence or fore and aftness may be concerned, he placed undoubtedly upon identically the same footing as original sensations themselves.[2] There should be no reasonable doubt, therefore, by any school, that Kant's real position as to the time problem was that all mental series whatever, however

[1] pp. 18, 21, 45, etc. No metaphysician excels Kant in precision in defining his faculties. We have *Vorstellen*, representation; *Wahrnehmen*, perception; *Kennen*, knowing; *Erkennen*, cognizing; *Verstanden*, understanding; *Einsehen*, perspecting; *Begreifen*, comprehending. See appendix, Tr. Critique, London, 1838. An intuition with Kant was not even a perception, because not conceived as implicating self-consciousness, p. 86. Much less did time intuition include the English act of memory.

[2] No student of Kant will declare that he conceived memory *necessary* to an intuition of time.

simple, or whether original sensation, or reproductions thereof, were necessarily and invariably accompanied by some vague awareness or intuition of their successiveness—their time order, and that the cause of this fact lay *à priori* in the soul; that the tying or joining lay altogether below the surface of consciousness in the substance of mind. It will be observed that in proportion as this conception expands in the mind and is extended over the whole range of associated reproductions, the less demand is there for any further explanation of memory; in fact, strictly speaking, this view does not require any further explanation for memory, and, as a final confirmation of the interpretation of Kant, which I have given, I would call attention to one of the most unique facts in all literature, (one I have nowhere seen mentioned), namely, that in Kant's Critique of Pure Reason, in which time-intuition plays such a preponderating part, both fundamentally to the system, and also in the page-surface of the book *the subject of memory is not once referred to, nor even the word memory or its equivalent once used, not even incidentally throughout.* This—unless in some obscure place, it has escaped my special search for it, line by line, from cover to cover. Nothing could more conspicuously emphasize Kant's preternatural genius for following out precisely and consistently any principle, right or wrong, once believed to be determined. Kant's entire system is built up on the *à priori*; and when we come to think of it, *à priori memory* would have contradiction in the very sound of it; and Kant, with instinctive and colossal consistency, actually builds up his system of mind utterly without memory.

Kant nowhere approaches discussion of particular time relations, or of how any one relation is intuited rather than another, and this is the whole problem. He tells us "time ever flows;" he does not make plain to us how his *à priori* conditions of the mind ever flow, and continually so adjust themselves that an event happening yesterday will inevitably be intuited by us to-day *as* yesterday, and a year from to-day be intuited by us as last year. Of one of a series of five notes,

[1] We do not intend to say he does not treat of memory in any of his works; he does so in the Anthropology.

say the fourth, it would be interesting to know what particular time order Kant would have conceived it *necessarily* to appear in; would it be as after the second, or as after the first, or only as after the third? or again perhaps would it be before the fifth? or if related to any event in particular, why not to one of last week, or to the last century, or to all events all together?

Thus it must be seen that Kant's own conception of an "intuition" of time, at best could have been but a vague awareness of succession in general or in the abstract,[1] and the close student of the time problem must judge for himself what that could really mean or how much he has gained by this, or by being told by Kant that time is an *à priori* form of mind.

MARCUS HERTZ[2] and other followers of Kant, wrote in explanation of his views of space and time which were adversely criticised, and particularly by ADAM WEISHAUPT.[3] JACOBI in defending empiricism, denied the *à priori* space and time; so also HERDER. SCHLEIERMACHER held space and time to be both forms of intuition and forms of objective things.

REINHOLD followed Kant in essentials, but turned the current of Germany toward "a single faculty." Perceiving Kant's confusion of causative form, with formed content, he confines his definition of time to the latter, but includes therein, as did Schleiermacher, both the matter and the form of the content. Yet this more objective ever-present time and space, which he calls "mere time" and "mere space," he insists is not empty time and space. What it is, as "ground form of all receptivity," he does not make quite clear. His struggle for more precise definition than his master, only brings more plainly to view the inherent vagueness of Kant's theory.

SCHULZE (Ænesidemus) and SOLOMON MAIMON threw over Kant's *Ding-an-sich*, and set the stream toward idealism. Still struggling with the "Unity of Diversity," they

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[1] p. 147.

[2] "Reflections in Speculative Philosophy." (Königsberg, 1771).

[3] "Zweifel über die Kant'schen Begriffe von Zeit u. Raum" 1787. The author has not been able to procure the above two works, and is unable to speak of them except at second-hand.

[4] "Versuch einer neuen Theorie." Buch III, S. 378–421.

reversed the usual deduction of time from the manifold—from "number of motion," and declared "Without space and time nothing would be discriminated, or separate in consciousness."[1] With them, time was as well a concept as an intuition.[2]

BECK has kinship with Jacobi and Reinhold, but particularly he influenced Fichte. It was Beck who introduced "*the mental act*" into philosophy; no phrase was ever more pregnant of systems. What this "mental act" is, other than the coming and going of mental content, I do not find them to have made comprehensible. A self-consciousness of the act is of course supposed to be involved. With Beck space and time are *Acts* of Synthesis; not Intuition, etc., but Intuiting, Representing, Perceiving. Before the synthesis space and time are not; they are generated in the act. Consciousness resulting from the synthetical act is "pure intuition." Continuation of the synthesis of space results in sequence. Synthesis of sequence is time. The act of synthesis must have a product; *i. e.* the spatial figure or the time must be fixed; this "fixing" of the product gives definite particular figures or times.[3]

FICHTE aspires to tell us the Why and the How, causative of mental life; to disclose that which Kant assumed as a beginning. He admits that his first step is purely an assumption, and that the consequences that can be made to result therefrom are the only warrant therefor.[5] He assumes the mental act of Beck,[6] then declares that every mental act presupposes a power or force. (Why more than it presupposes a thing forceful or a soul mindful?) Thus he transposes every mental fact into a mental act, and finds for each act a

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[1] Maimon's, Versuch über d. Transcendental Philos. S. 16–18.
[2] Ibid. S. 33, 36, etc.
[3] Einzig möglicher Standpunkt u. f. t. Abschn. II. § 3, § 141–167; Grundriss d. Kritischen Philos. I, § 10, 11. 12, 13.
[4] Samm. Werke (Berlin 1845), "Ueber d. Begriffe d. Wis. 1794," I, 70; "Fichte's Science of Knowledge," Tr. by Kroeger (London,1889), p. 49; Werke, "Grundriss," I, 411.
[5] "Begriffe, 1794," I, 58 sq.; 74; "Grundlage, 1794," 92, 101, 226, etc. Tr. p. 34 sq., 54, 64, 75, 185.
[6] "Grundriss," I, 333 sq.; Tr. p. 192; "Begriffe, 1794," I, 63, 70, etc.; Tr. p. 40, 49, etc.
[7] Grundriss I, 372; Tr. 221.

power; whereupon, strangely enough, he is able to reveal to us the truth that these powers so comport themselves as to produce and explain every possible mental phenomenon, thus entirely warranting and confirming his prime assumption. For example, a red spot appears to us spatially to exclude a blue spot: Fichte tells us that a red spot is a "deed-act," the blue spot another "deed-act," that all "deed-acts" mutually exclude each other, and *therefore it is* that red spots appear to exclude blue spots. Of course the value of such a system as this must depend somewhat upon the maker's preliminary interpretations of psychological facts; so long as psychology remains undetermined, or uncertain, the most that can be said for such a system would seem to be that "if things work in this kind of way, why! then this is the kind of way that things work."

According to Fichte, space deed-acts exclude or condition each other co-existingly above, below, etc. Time deed-acts condition each other in the order of a series, that is: Of a series A, B, C, D; C conditions D; B conditions C; A conditions B; A is unconditioned of B, C, or D; B is unconditioned of C or D; C of D. Thus conditioned we *must* think them in the order of their series.[2]

Fichte adds the weight of his opinion to the theory that "There is for us no *past*, except in so far as it is thought in the present . . . Whatsoever was yesterday *is not;* it *is* only in so far as I think in the present moment *that it was.* . . . Of course a time is past, if you posit one as past; and if you ask that question (is it past?) you do posit a past time; if you do not posit it you will not ask that question, and then no time has past for you."[3] Thus time with Fichte is a present thought.

SCHELLING characteristically defines time as "The I itself thought in activity."[4] Erdmann finds Schelling's deductions of space and time "most interesting" in connection with the

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[1] Grundriss 391–405; Tr. 235–249. Also, see Kuno Fischer, Geschichte d. n. Phil., V, 476, u. s. f.
[2] Grundriss 405–411; Tr. 249–255; Kuno Fischer, V, 476.
[3] Grundriss 409; Tr. 253.
[4] Tr. Idealism. Ep. II; D, III, S. 467.

"distinction of outer and inner sense in consciousness;" also, his combination of space and time with the categories.[1]

HEGEL devotes §§ 257–260 of his Philosophy of Nature to time, and treats the subject less particularly in various places. Translated into ordinary language, § 257 tells us that time involves existence or being; § 258 that it involves ceasing to exist, and coming into existence, *i. e.* change and "becoming." Then follow discussions of duration and eternity. No man will more rightly appreciate Hegel than the psychologist who sits down to discover precisely what the "Great Master" really tells him about some definite modern problem, say time. Imagine his satisfaction at having it revealed to him at the outset that "the Present" is "the transition of Being into Nothing, or of Nothing into Being" (§ 259). A watchmaker might be equally pleased to learn in some supposed supreme treatise on his art, that a chronometer is a continued Identification of the Now. Perhaps the most definite thing regarding our subject which we learn of Hegel, is that, in comprehensible moods, he classed time as a "Pure form of Sensibility." (§ 258).

ARTHUR SCHOPENHAUER declares "From Kant's doctrine of the Transcendental Aesthetic, I know of nothing to take away; only of something to add." What he "adds" particularly for us, the following will indicate: "Time is primarily the form of inner sense. . . . The only object of inner sense is the individual will of the knowing subject. Time is therefore the form by means of which self-consciousness becomes possible for the individual will, which originally and in itself is without knowledge. In it the nature of the will, which in itself is simple and identical, appears drawn out into a course of life."[3] Also, "Time, space, and causalty are that arrangement of intellect by virtue of which the *one* being of each kind which alone really is, manifests to us a multiplicity of similar beings, constantly appearing and disappearing in endless succession."

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[1] Gesch. d. Philos. § 318. Tr. p. 567.
[2] World as Will and Idea. Tr. Haldane and Kemp. (Boston, 1888) Vol. II, p. 33.
[3] p. 207.
[4] p. 224.

In a more empirical mood he declares "Succession is the whole nature of time";[1] this is adverse to the side of the great debate which Fichte took in declaring time to be not "succession" but a "present thought."

CHR. HERMANN WEISSE and I. H. FICHTE (half-Hegelians) criticised their master for not treating space and time as any of the other categories of knowledge or "forms of reality," and in his Logic rather than in his Philosophy of Nature.[2] Fichte developed space and time from certain "*feelings of duration and extension which are inseparable from self-consciousness, and which feelings have their basis in the soul's own objective nature.*"[3] From a similar standpoint, E. H. WEBER, in 1852, coined the now famous phrase "*The Space-sense,*" and following him CZERMAK first used its analogue "*The Time-Sense.*" These are important events in the experimental history of time. Weber and Czermak looked upon space and time as being senses as disparate as sight and hearing. Yet from their universality they called them General Senses as opposed to the special.[4]

FRIES was most influenced by Jacobi, but declaredly clung to Kant's views of time.[5] Yet he distinguishes between *à priori* "cause" of intuition, and intuition *per se*.[6] He begins to take the bodily organism a little into account,[7] and was troubled as to what *particular* time-relations would be perceived from Hume's mere sequence of notes; but he thought "in some sort of a way I get possession of these co-existently" (p. 142). He vaguely described this "some sort of a way" as "a fundamental determination or fixing of the mind."[8] He declares that all sense perception must appear in the mind "joined" (*verbunden*). Particular time-relations Fries derives from the "reproductive" and "produc-

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[1] p. 9.
[2] Article by Weisse in Fichte's Zeitschrift, 1837.
[3] Ibid, new Vols. 55, p. 237 sq.; Vol. 56, p. 47, sq.
[4] Weber, Berichte ü. d. Verhandlungen, d. K. S. G. W. Math. Physische Classe, 1–4, S. 85. Jahrgang, 1849–52. Czermak — Gesamm. Schriften, I, 416.
[5] Kritik d. Vernunft (Heidelberg, 1828), Vol. I, p. 173, etc. Erdmann's Hist. Philos. (Tr. 1890), II, 454.
[6] p. 173 sq.
[7] p. 94.
[8] p. 69, 106, 110, 120, 124, 141, *171*. 174, *177 sq*. 188.

tive powers of Imagination"; by which they are "attributed" their proper time-aspect in the passing content of mind.[2] In proportion as he conceived the course of our thoughts to be determined at will, these time-aspects were bestowed voluntarily.[3] Yet more than any German of his day he gave consideration to the rôles which memory,[4] association, habit, training,[7] "former occurrence,"[8] "fading,"[9] etc., play in "mental inter-determination." In these he is abreast with the best of the Scotch-English school of his day. In all but the vague "some-sort" of intuition of sequence, Fries' time-relations are *perceptive acts*.[10] He also inclined to a more objective conception of space and time than Kant, in that he at times conveys the idea that space is "visible extension void of particular or limited content"; and that time is some sort of analogous objective inner sense. Fries is also more generous to realism than Kant, and is inclined to conceive relations actually existing between things, to which in themselves he consequently carries over Space, Time, Motion and Change.[11] In view of the importance which the phrase, "The idea of succession is not a succession of ideas" assumes in subsequent stages of the discussion, it is important to note that Fries apparently was the first definitely to emphasize the declaration that "all the terms or elements of unification, comparison or relationship must be before consciousness at the same time."[12]

Thomas Reid deserves great credit for bringing out many of the difficulties of the problem to clear and simple view. He declares: "I think it would be impossible to show how we could acquire a notion of duration, if we had no memory." This is against Kant's view. "Memory implies a conception and a belief of past duration. . . . Remembrance is a

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[1] p. 102, 137, 145, 161, *175*, 177, 178 sq., 185, 188, 192.
[2] p. 161, *175*.
[3] p. 77, 83, 163, 185, 187 sq., 196.
[4] p. 135 sq. 161, 165.
[5] p. 142, 148, 153 sq., 160, 162 sq., 187 sq., 193.
[6] p. 168.
[7] [8] p. 137, 160, 162 sq., 165.
[9] p. 138.
[10] p. 86.
[11] p. 77, 83, 163, 185, 187 sq., 196.
[12] p. 141, 180.

particular act of the mind of which we are conscious. . . . I believe that I washed my hands and face this morning; how do I come to believe it? I *remember* it distinctly—that is all I can say. . . We know many past events by memory; but how it gives us this information I believe is inexplicable. . . . I think it appears that memory is an original faculty, given us by the author of our being of which we can give no account, but that we are made so. . . . All our original faculties are unaccountable."

Yet Reid makes contributions to the time-problem. He takes Locke to task for confounding succession with duration: "the notion or idea of duration must be antecedent to its being measured"—to succession.[1] Also we must crown Reid for grasping more definitely than anyone before his time this cardinal aspect of the subject: "It may be observed," he says, "that if we speak strictly and philosophically no kind of succession can be an object of either the senses or of consciousness; because the operations of both are confined to the present point of time, and there can be no succession in a point of time; and on that account the motion of a body, which is a successive change of place could not be observed by the senses alone without the aid of memory" (p. 348). Criticising Hume for saying that impressions reappear, he declares "the thing is impossible." "Impressions are fleeting perishable things, which have no existence but when we are conscious of them" (p. 357). He makes rather lame fun of Hume's explanations of time by "reappearances of varying intensity." "Suppose a man strike his head against the wall, this is an impression; now he has a faculty by which he can repeat this impression with less force. . . . This by Mr. Hume's account must be memory" (p. 357). Reid admits that "it is probable that in the human frame memory is dependent on some proper state or temperament of the brain; yet says he "if we knew distinctly that state of the brain which causes memory we should still be as ignorant as before how that state contributes to memory" (p.354); "an ability to revive our ideas or perceptions after they have

[1] Works. Edinburgh, 1872, p. 339–360.

ceased to be, can signify no more but an ability to create new ideas or perceptions similar to those we had before" (p. 355). How we recognize perceptions we have had before, is to Reid inexplicable.

DUGALD STEWART advances our problem only in a general way by forcible analysis of such questions as Identity, Association, Memory and Reason. He says, "the idea which is commonly annexed to *intuition* as opposed to *reasoning*, turns, I suspect, entirely on the circumstance of time."[1] "For this reason I look upon the distinction between our intuitive and deductive judgments as, in many cases, merely an object of theoretical curiosity" (p. 71). He declared like Reid "the theories which attempt to account for the phenomena of memory by means of impressions and traces in the brain, are entirely hypothetical, and throw no light on the subject which they profess to explain" (p. 393).

THOMAS BROWN deserves conspicuous rank among the Fathers of Psychology. One of his services was to disclose (it is not yet dispelled) what Prof. James calls the "Great Psychological Fallacy;" this consists in unconsciously carrying over and accrediting to some psychological act or phenomenon which we may be analyzing, those other feelings, mental acts or states which we have *while* introspectively making this analysis. This fallacy had led to the great debates before Brown's day, relative to the distinction between sensation and perception, till then it having been almost universally maintained that perception included self-consciousness, a knowledge of *a* mind looking on *at* mind. Brown says, "to me it appears, that this attempt to double, as it were, our various feelings, by making them not to constitute our consciousness, but to be the object of it, as of a distinct intellectual power, is not a faithful statement of the phenomena of the mind. . . . . Sensation is not the object of consciousness different from itself, but a particular sensation is the consciousness of the moment. . . . 'I am conscious of a certain feeling' really means no more than 'I feel in a certain manner.'"[2] Also Brown's revelations regarding the genesis and make-up of

[1] Works—(Cambridge, 1829), II p. 69.

[2] "Lectures on the Philosophy of the Human Mind." (Philada. 1824), Vol. I, p. 135, sq.

our conception of space are important contributions to psychology; from these he carried over certain analogous determinations to the enrichment of the time problem. Having deduced the notion of space from motion, and that of length from continued or successive motion, he conceived the origin of the idea of time to lie in identically the same thing—that length of extension and length of duration are ultimately one —(p. 305). He discovered this element of length in all mental processes. "Continuous length and divisibility, those great elementary notions of space and time and of all that space contains, are thus found in every succession of our feelings" (p. 306). He also gives us a nearer view of their development. "If," says he, "we gradually extend our arms in various directions, or bring them nearer to us again, we find that each degree of the motion is accompanied with a feeling that is distinct, so as to render us completely conscious of the progression. The gradual closing of the hand, therefore, must necessarily give a succession of feelings, a succession, which of itself might, or rather must furnish the notion in the manner before stated, the *length* being different according to the degree of the closing, and the gradual stretching out of the arm gives a succession of feelings, which in a like manner must furnish the notion of length—the length being different according to the degree of the stretching of the arm. . . . The Infant . . . by frequent renewal of the series of feelings involved in each gradual contraction, cannot fail to become so well acquainted with the progress as to distinguish each degree of contraction, and at last, after innumerable repetitions, to associate with such degree, the notion of a *certain length of succession*. . . . In these circumstances of acquired knowledge (after the series of muscular feelings, in the voluntary closing of the hand, has become so familiar, that the whole series is anticipated, and expected as soon as the motion has begun) when a ball or any other substance, is placed for the first time in the infant's hand, he feels that he can no longer perform the usual contraction; or in other words, since he does not fancy that he has muscles which are contracted, he feels that the usual series of sensations does not follow his will to renew it; he knows how much of the

accustomed succession is still remaining, and the notion of the particular length which was expected and interrupted by a new sensation, is thus associated with the particular tactual feeling excited by the pressure of the ball. . . . By frequent repetition and association . . . these two feelings flow together; . . . it becomes, at last, as impossible to separate the mere tactual feeling, from the length of feeling (time) as to separate the whiteness of a sphere in vision, from that convexity of the sphere, which the eye, of itself, would have been forever incapable of perceiving" (p.309 sq.). "The series of muscular feelings of which the infant is conscious . . . must on these principles, be accompanied with the notion . . . of a certain length of succession, and each stage of the contraction, by frequent renewal, gradually becomes significant of a particular (time) length corresponding with the portion of the series" (p. 297). These deductions hold of all, as well as of the muscular sense. "Time or succession then, involves the very notion of longitudinal extension and divisibility and involves these, without the notion of anything external to the mind itself; for though the mind of man had been susceptible only of joy, grief, hope, and the other varieties of internal feeling, *without* the possibility of being affected by external things, he would have still been capable of considering these feelings as successive to each other in a long continued progression, divisible into separate parts. The notion of length, then, and of divisibility, are not confined to external things, but are involved in that very memory by which we consider the series of the past, not in the memory of distant events only, but in those first successions of feeling by which the mind originally becomes conscious of its own permanence and identity. The notion of time, then, is precisely coeval with that of the mind itself; since it is implied in the knowledge of succession, by which alone, in the manner above explained, the mind acquires the knowledge of its own reality, as something more than the mere sensation of the present moment. Conceiving the notion of time, therefore, that is to say, of feelings past and present, to be thus one of the earliest notions which the infant mind can form, so as to precede its notions of external things, and to involve the

notions of length and divisibility, I am inclined to reverse exactly the process commonly supposed, and instead of deriving the measure of time from extension, to derive the knowledge and original measure of extension from time" (p. 307).

This is one of the most noteworthy passages in the history of our subject; particularly so when we compare its truly remarkable penetrations and suggestiveness with its glaring contradictions; evidently the crucial question, whether time is an idea or a succession of ideas had not come to a focus in the mind of this acute psychologist; within short spaces he confounds the two concepts in a way that must necessarily lead him to false conclusions.[1] All through the above discussion we have been led to believe that the idea of time lies in the successions themselves, in precisely the same way as Brown took so much pains to explain that "perception of a sensation" was the sensation itself; but the moment he takes up the subject of time under another aspect—that of memory or of relations—his traditions prove stronger than his originality, and he tells us that "*certain feelings of relation*" constitute our notion of time.

Before examining this let us make sure what, in the conception of this great mental-chemist, these "relations" were. He says, "the feelings of relations are states of the mind essentially different from our simple perceptions or conceptions of the objects that seem to us related, or from the combinations which we form of these in the complex grouping of our fancy." "There is an original tendency or susceptibility of the mind, by which on perceiving together different objects, we are instantly, without the intervention of any other mental process sensible of their relations in certain respects, as truly as there is an original tendency or susceptibility of the mind, by which, when external objects are present and have produced a certain affection of our sensorial organ, we are instantly affected with the primary elementary feeling of perception." "As our sensations are of various species, so are there various species of relations . . . the number of relations, indeed, even of external things being almost infinite," etc., (p. 146).

[1] Compare p. 297 with p. 307.

We now may understand Brown when he says "time, as far as we are capable of understanding it, is nothing more than the varieties of the felt relation; which in reference to one of the subjects of the relation we distinguish by the word *before*, in reference to the other, by the word *after* . . . All of which we can be said to be *conscious*, is certainly the present moment alone. But of that complex state of mind, which forms to us the present moment, there are parts which impress us irresistibly and beyond all the power of scepticism with the relation, which, as I have already said, we term *priority* in reference to the one, and *succession* or *subsequence* in reference to the other; time as felt by us, being this relation of the two and nothing more."[1] . . . "It is a relation we may remark, which we feel, nearly in the same manner as we feel the relation which bodies bear to each other as co-existing in space."

This last is remarkable from one who has deduced space from time—from the mere successive feelings of "length" in stretching the arm. Also Brown's genesis of time as detailed above, and his notion that time is one of the earliest notions of the infant, "preceding its notion of external things," are difficult to reconcile with his declaration that "if we had been incapable of considering more than two events together, we probably never should have invented the word time" (p. 90). We have to regret that Brown did not give the same weighty scrutiny to "relations" which he gave to the analysis of space.

Brown developed further the common doctrine of association or "suggestion" as he termed it, by adding thereto a further class or realm, of association among "relations"; the former he termed "simple suggestion;" the latter "relative suggestion." Among these last he classed time perception. Thus it must be observed, though arrived at from entirely different standpoints these "*feelings* of time relation" are essentially kin to the disparate "time-sense" of Czermak and Vierordt, and the time "feeling" of I. H. Fichte, and as we shall see later of Horwicz, and James.

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[1] Ibid, Vol. II, 91.

Sir William Hamilton falls back from Brown toward Kant. He nowhere gets beyond the antique vagueness that "time is the necessary condition of every conscious act."[1]

Herbart is the Morning Star of modern German Psychology. Schwegler describes his system as "an extension of the Monadology of Leibnitz."[2] Herbart's monads, however, are "eternally unchangeable," and in place of the Pre-established Harmony of Leibnitz, the reciprocal interactions of the monads or "reals" are the direct cause of their intelligence. The diversities of mental content are primarily due to respectively diverse kinds of "reals"—for every red, shrill or cold sensation, a red, shrill, or cold monad.[3] Mind as the product of the interactions of these monads is a mathematical mechanism.

The following indicates Herbart's mechanism of time. Some "real" attacks our "real" (the soul) which "seeking to preserve its own condition," a corresponding sensation *a* results; *a* thus rises in consciousness till equilibrium is reached between the force of the "real" and the "self-preserving" force of the soul; *a* "sinks" as the soul gains the mastery and restores itself by expelling the attacking "real." The level at which any consciousness begins is its "threshold."[4] If while *a* durates in consciousness, another sensation *b* similarly rises, then *a* and *b* "fuse" (associate) proportionately to their "remnant" or remaining co-presence, height or intensity in consciousness; thereafter, whenever either *a* or *b* appears in consciousness, it tends to bring back the other with a force proportional to the above "fusion." If *a b c d* rise in an original sequence, and *a* by any cause be brought back into consciousness, it will tend to bring with it *b; b* to bring *c;* and *c* to bring *d;* thus the whole series will repeat itself in the time order of its original occurrence.[5] If, moreover, at any time thereafter *c* be the first of the series to be brought back, then its influence will work in two directions; the series *c d* will repeat itself as in the original

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[1] Lectures (Boston, 1871), I, 548.
[2] Hist. Philos. (Sterling Tr. Edinburgh, 10th Ed.) p. 285.
[3] Lehrbuch zur Psychol., § 150 sq., etc.; Allgemeine Metaph. § 312, "Wie viele Merkmale—so viele Ursachen."
[4] Lehrbuch, ch. 1.
[5] Ibid. § 29 sq.

sequence; but at the same time *c* will act both upon *b* and upon *a* in proportion to its former "fusion" with each of these; consequently, while *c d* reinstates itself as a "series of evolution," the combination *a b c* rises simultaneously through "involution" *c* appearing brighter than *b*, and *b* than *a*, *i. e.*, fixedly in proportion to their original fusion—that is again, in brightness proportional to the time-order of their original appearance.[1] These laws may be carried out through all the familiar complexities of Association, "series and ever-compounding series of series" being substituted for the letters of our formula.

But in particular how are time-perceptions formed? Suppose an original series *a b c d e*, as above. Should *a* be again presented the series tends to repeat itself by "evolution" in its original direction. Should *e*, however, be the first to appear of a re-presentation, then the series tends to be brought back as a whole, co-existently and by the above process of "involution." Finally, should *a* and *e* be reproduced *simultaneously*, a compound result would now occur; a result including and combining both the previously mentioned results: that of the "involution," occurring from *e*, and the "evolution" following from *a*. In this final process, it will be observed, are involved three requisites: (1) *The involutive product*—in which all the members of the series are simultaneously represented, but each with a brightness corresponding to its time order or degree of "fusion" in the original sequence. This may be called the *presentation of the series.* (2) *The evolutive product*—which is an actual re-occurrence of the original series in the same time order, and each member in proportion though not with equal brightness, with that in which it first appeared. This may be called the *presentation of the succession*—that is, of the process itself or of change. (3) By the combination of (1) and (2) the two end terms of a series are presented in a proper double simultaneous relation, that is as both co-existently *present*, yet both also in serial perspective of fixed single direction. This may be called *the presentation of their terminal time-relation.* Thus in (1), (2) and (3) together, we have the three elements,

[1] Ibid. § 167 sq.; 75 sq.; 89 sq; Psych. als W. § 94, 112, 115.

which Herbart conceived to be essential to a complete perception or idea of time; namely: An idea of the series, an idea of succession or change, and an idea of definite terminal relations.[1]

Suggestive as is the method, and scientific as is the spirit of Herbart's time theories, it is of chief importance for us to note accurately Herbart's true position regarding time-perception as an instantaneous state, or a succession of states; this especially because of the weight of Herbart's opinion as an authority; of his great influence upon the German Psychology of to-day; of the constant misconception and misquotation of his opinion, and of the crucial value of the question itself. By holders of the first view, much is made of Herbart's phrase, "Succession in presentation is not a presentation of succession."[2] While to any student of Herbart it is plain that *not every* succession of mental content suffices to constitute or yield an idea of time-relation, yet it is just as plain that no single *simultaneous* condition of mind does or can constitute the same. Herbart's time-perception is a three-fold *process*—not a single present *state*. It is also important to note that Herbart imports into his three-fold process no extra or disparate sense or feeling; *Herbart's perception of time-relation, consists of certain proper successive combinations of our ordinary sensations or feelings, or of their reproduced representatives.*

Friedrich Eduard Beneke founded a new psychological system more or less kin to that of Herbart and to the English Empirical School, but he gave no new explanations of time.[3]

Moritz Wilhelm Drobisch, a disciple of Herbart, declared space and time to be but "forms of succession" (*Reihenformen*).[4]

Theodor Waitz, from an Herbartian starting point,[5] introduces a new aspect of the problem—one that assumes great importance in the modern psychology of Wundt, Münsterberg,

[1] Ibid. § 167 sq.; § 75 sq.; § 89 sq. Psych. als W. § 94 sq.; § 112 sq.; § 115.
[2] Lehrbuch zur Psych. § 174; Allg. Metaph. ch. 1 sq.
[3] "Die neue Psych." Berlin, 1845; Lehrbuch d. n. Psych. 2d Ed. (Berlin, 1845); Pragmatische Psych. (Berlin, 1850), 2d Ed.
[4] Empirische Psych. (Leipzig, 1842), p. 67.
[5] Lehrbuch der Psych. (Braunschweig, 1849), p. 580, 583.

et al. He points out that "certain conditions of feeling" such as constitute waiting, impatience, tediousness, straining of attention and the like, always accompany our objective contents of thought; and he holds that these are fundamental in the formation of our time percepts. The process by which this happens is not unlike that given above from Thomas Brown. A well remembered series of these obscure inner feelings, that is, a series of them which has been frequently repeated in us, is compared with, that is, "*runs its course simultaneously with*" a new objective series, say of vision: the new visual series over-runs, or runs short of the old constant series of feelings, and the shortage or overplus of these last constitute our means of judgment, or time-measures of the new series. These overplus and shortage earmarks become "fused" or associated with all sorts of combinations and abstractions, and form the fundamental measure elements of all our time concepts.[1]

Rudolph Hermann Lotze, notwithstanding his eminence in modern philosophy and the originality of his determinations regarding "local signs" and space, adds little to the discussion of the time problem. He believed in the "power of the soul to preserve impressions independently of physical conditions."[2]

Heinrich Czolbe, of all moderns, must be credited with the most unique view of time. He regarded all sensation as extended in space, and time as a fourth dimension of space.[3]

Wilhelm Rosenkrantz, last of the School of Schelling, newly discussed time as a category or form of thought in its intercourse with the outer world.[4]

Leopold George, pupil of Schleiermacher and Hegel, declared: "By means of memory the moment of time is introduced in the [*i. e.* his] system of localized points"; but "memory does not reproduce traces of sensation as is generally thought, but reproduces combinations, the occasions

[1] Ibid. § 52.
[2] Medicin. Psych. § 36, p. 473.
[3] Posthumous Work, "Outlines of an Extensional Theory of Knowledge. Edited by Dr. Johnson (1875). Compare with this from Diogenes L. VII, 141, "Time is the extension of the motion of the world (*διάστημα τῆς τοῦ κόσμου κινήσεως*). It is infinite both in the direction of the past and of the future.
[4] Die Wissenschaft des Wissens (Munich).

for which have been supplied by the sensations."[1] Particularly he combats the time theories of Trendelenburg.

TRENDELENBURG, going back to Aristotle, held space and time to be products of motion.[2] In opposition to Kuno Fischer he particularly criticized the time theories of Kant and Herbart.[3]

ULRICI examines the subject from the stand-point of "Speculative Theism," and semi-Hegelianism, but gets little further than such declarations as that "Thought is bound by certain rules, of which time is one."[4]

FECHNER discusses time, space and motion, as it would seem, with particular reference to the writings of Trendelenburg, but without his usual originality.[5]

BRENTANO, Professor of Philosophy at Vienna, in his Psychologie vom empirischen Standpunkte (Leipzig, 1874), gives an interesting exposition of the views of a certain current transitional school, but does not focus definitely on the subject of time.

HORWICZ is a prominent advocate of the modern tendency to make physiology the sole source and guide of both psychology and philosophy.[6] The metaphysical question of *how* the body excites any feeling at all in the soul, he considers vanity and folly. (I. 143). Soul is "a collective designation for all psychic phenomena." (I. 135). He reduces all of mind to simple elements of "feeling." Change in feeling follows change in nerve substance. (2 Vol. III, 41). "All soul processes are built up (of the ultimate feeling elements) through repetition and complication." (I, 202). Frequence of repetition plays the fundamental rôle (p. 345 sq.). Certain frequency gives us sight, another sound, etc. Time-sense, and space or place sense are special senses to be classed

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[1] Lehrbuch der Psych. (Berlin, 1854). p. 222, 399.

[2] Logische Untersuchungen (Berlin, 1840). Vol. VI.

[3] Vol. III. Hist. Beiträge zur Philos.; (pamphlet) "Kuno Fischer und sein Kant" (Leipzig, 1869); K. Fischer's Geschichte d. neuren Philos. (2d ed.) Vols. III and IV, 1869.

[4] Das Grundprincip der Philosophie, Leipzig 1845–6; System der Logic (1852); Compendium der Logik (1860 and 1872); Outline of Practical Philos., pp. 1–208.

[5] Physik. u. Philos. Atomenlehre (Leipzig, 1855–1864). Appendix.

[6] Psychologische Analysen auf physiologische Grundlage, 1st Part. Halle, 1872, 2d Part (2 Vols. Halle und Magdeburg, 1875–1878).

with sight, hearing, etc. (p. 340). This, though time appears *only with* and *always with* other sensation. Horwicz's classification of the senses, according to their *objectivity*, is strangely in opposition to Kant: "Objective (end of scale); Time-sense, space-sense, eye, ear, pressure, temperature, smell, taste, general feeling of the skin, feeling of the organism or general feeling; subjective (end of scale.)"

Sensations, on their physical side, leave effects in the nerve elements, which are the basis of our ideas or reproduced sensations. Metaphysical identity Horwicz declares to be an insolvable metaphysical question, but mental or objective identity is at least an "unsuspected likeness" (p. 107). From reappearances of these unsuspected likenesses under the usual laws of reproduction and association, Horwicz builds all our concepts of memory and of time-relation. He plants himself unmistakably on the side of those who declare all perceptions of time-relation to be only certain successions of properly compounded sense presentations, or feelings.

Horwicz betrays the influence of modern experimental time psychology; rhythm now plays the important rôle. Rhythm he declares to be the measure and the only measure of time; a being incapable of regular periodic intervals could attain no conception of time. All the rhythmic functions of the body serve this purpose; as breathing, pulse, leg-swing and other such movements, hunger, sleep, labors, duties, customs of all kinds. Thus our time measures spring from and enter into the most fundamental and most subtle depths of our being (III, 145).

Wilhelm Wundt, at present the most conspicuous figure in German Psychology, has given us positive determinations of unusual originality and value; this whether the merit of his system be as entirely obvious or not.[1] He reduces all mind to ultimate elements of "will;" indeed, elementary acts of will, as activities, rather than as sensations, are the ultimate constituents of the entire universe.[2] Higher manifestations of these elementary will components are feelings and

[1] For English criticism see "Mind," January, 1890.
[2] System der Philosophie (Leipzig 1889), p. 438

sense-perceptions. Combinations again of these last mentioned products, give us sensations proper, but as a matter of fact, we never experience even sensations, as single elements, but alone complex combinations of them, such as our ordinary complex sights, sounds, etc.[1] The nature of this lowest element of mind is, however, that of a judgment; in the merest experience, say of red, is a recognition—a judgment of it as red. Therein lies the root and nature of all reason, of all mental acts; which acts are but complications or compilations of elementary willful judgments.[2] Inherent in the nature of this ultimate unitary judgment, is the problem of recognition of identity.[3] Why elements of mind exist at all we do not know; why diversity rises from these units we do not know; why we judge or identify the diverse we do not know. That we *do* these things is assumed as an ultimate fact. From these ultimate assumptions all mind develops; the processes of its development are alone the province of psychology; what may lie back of these is the province of metaphysics.

In the same way that the *content* of mind is ultimately incomprehensible, so also is the fact that its diversities succeed each other; the nature and the manner of these successions is all that psychology can study. All mind then is but a succession of diversities; certain of these we call ideas, perceptions, conceptions or postulates — among others are those of time.[4] Yet not every mental succession suffices to constitute an idea or perception of time—an idea or even the simplest possible perception being a highly complex product. The crucial process of time-perception Prof. Wundt describes as follows: "Assume that . . . similar pendulum strokes follow each other at regular intervals in a consciousness otherwise void. When the first one is over, an image of it remains in the fancy until the second succeeds. This, then, reproduces the first by virtue of the law of association by similarity, but at the same time meets with the aforesaid persisting image. . .

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[1] Grundzüge der Physiologischen Psychologie (Leipzig 1887) II, 226.
[2] System, p. 573.
[3] System, p. 504.
[4] System, p. 428 sq; 431 sq.

Thus does the simple repetition of the sound provide all the elements of time-perception. The first sound [as it is recalled by association] gives the beginning, the second the end, and the persistent image in the fancy represents the length of the interval. At the moment of the second impression, the entire time-perception exists at once, for then all its elements are presented together, the second sound and the image in the fancy immediately, and the first impression by reproduction. But, in the same act, we are aware of a state in which only the first sound existed, and of another in which only its image existed in the fancy. Such a consciousness as this is that of time. . . . *In it no succession of ideas takes place.*"[1]

It can not fail to be observed that the above time-perception is a *process* and not a *state*. Notwithstanding Wundt's last words in italics this process is surely a succession of some kind or kinds; though of course it is not a "succession of ideas," if by idea is meant the process as a whole. There seems no good reason for confusion on this point.[2]

Prof. Wundt discusses constancy (duration), change, and rhythm with perspicuity and truth.[3]

Prof. Lipps one of the representative German Psychologists describes the time-process as follows: "Sensations arise, occupy consciousness, fade into images and vanish; according as two of them, *a* and *b*, go through this process

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[1] Physiological Psychol. 1st Ed. p. 681-2. Tr. in James' Psychology, Vol. I, 608. James adds "note here the assumption that the *persistence* and the *reproduction* of an impression are two processes which may go on simultaneously. Also that Wundt's description is merely an attempt to *analyze the deliverance* of a time-perception, and no *explanation of the manner in which it comes about.*"

[2] Prof. Wundt contributes confusion as follows: Logik p. 432. "Die Vorstellung zeitlicher Aufeinanderfolge ist nicht selbst eine Aufeinanderfolge von Vorstellungen, sondern eine aus der letzteren hervorgehende *simultane* Anschauung, in welcher sich die Wahrnehmung zweier getrenter Vorstellungen, die als Anfangs- und Endpunkt einer Zeitreihe gegeben sind, mit dem Bewusstsein eines sie trennenden andersartigen Inhaltes verbindet. Dabei kann dieser letztere, entweder bloss aus der Nachdauer der ersten Vorstellung, oder ausserdem, aus neuen Vorstellungen bestehen, deren Nach-wirkungen zu derjenigen einer ersten Vorstellung hinzu tretten. Wesentlich für die Anschauung der Zeit, ist somit, einerseits die Verbindung verscheidener getrennter Vorstellungen mittlest der Reproduction, und anderseits das ebensfalls durch Reproduction vermittelte Bewusstsein ihrer Trennung."

[3] p. 435.

simultaneously, or as one precedes, or follows the other, the *phases of their fading* will agree or differ; and the difference will be proportional to the time-difference between their several moments of beginning. Thus there are differences of quality in the images, which the mind may *translate* into corresponding differences of their temporal order. There is no other possible middle term between the objective time-relations and those in the mind than these differences of phase."[1]

Prof. Lipps calls these "temporal signs"; what his process of mental translation of these signs may be is difficult to conceive, and it were about as easy to call the whole problem an inexplicable mystery and be done with it.

Ernst Mach, a prominent representative of the experimental school, also carries back our problem to a special time-*sense* or feeling, "as special as that of color."[2] He says we can separate the rhythm of a melody from the tone, as much as the contour from a painting, and that this would not be possible were the rhythm not a separate series. He suggests that there may be in the ear some accommodation apparatus like that of the eye, which may be the organ of the temporal sense. Time-sense, therefore, would be, and is closely allied to the workings of attention; certain "fixation" sensations arise from this accommodation organ, varying according to intensity, duration, pause, etc.; a greater amount of attention always indicates the *later* impression; this happens by reason of association with sense of fatigue of the organ. "But adapted condition" would in time be called up by external happenings, as in eye-adaptation and these called-up ear-marks thus give us temporal distance and sequence, in the same way as we get visual distance and perspective.[3]

Dr. Hugo Münsterberg finds in respiration a solution of the time-problem (analogous to Mach's theory above) which

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[1] Grundtatsachen des Selenlebens (Bonn, 1883). p. 588. Tr. James' Psy. p. 632.

[2] "Untersuchen über den Zeitsinn des Ohres," § IV. "Beiträge zur Analyse der Empfindungen," pp. 6–14.

[3] Ibid, p. 103 sq.

will be considered presently in connection with the work of other experimentalists.

Prof. WILHELM VOLKMANN discusses time with his usual comprehensiveness. A brief review of his discussion will close the history of the German schools, and thus, what may be considered a fair representation of the latest status of our problem in that country, will be brought into close comparison with the views of James Mill of the English school, which will then follow.

The general system of Volkmann is so essentially that of Herbart as to need no further exposition here. Regarding time, however, Volkmann takes a more literal position than his master as to whether the idea of succession is or is not a succession of ideas. He says: "Indeed when one considers the matter precisely, he discovers the antithesis, that the presentations *A* and *B*, in order to be perceived as successive, must be presented simultaneously; that is, in order to *appear* to be after each other, they must *be* present."[1] "In order to become conscious of a presentation as ended, we must bring it into some other presentation which appears to us as going on." In original sensations as opposed to their reproduced images he finds the requisite data of distinction for the "going on;" these form our present. Of a succession of sensations *A B C* only one is present—"the present of one excludes that of the others. But this exclusion is purely negative; if a time-presentation is to arise, the not-present (say of *A* and *C*, while *B* is present) must be raised from the negative to the positive form." "This happens in that *A* and *C* (while *B* is present) each in a different manner, continue to influence B" (according to ordinary Herbartian psycho-mechanics). *A*, although having passed out of the focus of sensation, struggles to preserve to itself that condition as against *B*; *B* repells this endeavor, and in the reflex, which the presentation of *A* in itself suffers, lies the perception *(Bewusstwerden)* of time as *a quality of A*, *i. e.* the perception of it as "no more." Thus with Volkmann this secondary reflex feeling of strife,

[1] Lehrbuch der Psychologie von Standpunkt des Realismus (Cöthen, 1885), II, p. 12.

suffered by reason of the contention of the sensations themselves for the focus-point or present of consciousness, is the essential element of time-perception. Similarly to this struggle of "no-more," or "feeling of past," of *A*, is developed the "not-yet" of *C*, *i. e.*, the feeling or intuition of future. The time-sense with Volkmann is, therefore, more thoroughly a disparate sense, though also a "general sense," than even sight or hearing.

"No-more and not-yet," he continues, "are the specific *(eigentlichen)* time-feelings, and we should never become conscious of time otherwise than through these feelings. . . . When a series has once taken on this time-form (as above) it preserves the acquired characteristic, in future reproduction of the same, but only when, and in so far as the same conditions are renewed, under which the original time-form was developed. . . . The presentations *(A B C)* remain what they are, but the manner of their presentation changes; all time-consciousness, as feeling, is a perception (*Bewusstwerden)* of presentations" (§§ 86, 87).

Regarding duration, a corresponding struggle to that of "no-more" and "not-yet-there," gives us the feelings of "yet-there." Complications of these constitute our feelings of tediousness, ennui, expectation, monotony, haste, fast, slow, etc. "The rise and fall of these strifes, bring into the life of the individual certain rhythms" which become our measures of duration and of time. So separate is the *sense* of time from the *content*, that various presentations may produce the same feelings of time or of duration, *i. e.*, the same perceptions of time-length and time-relationship (§ 88).

Upon these main principles, Volkmann develops all the more varied and complicated time concepts, up to those of eternity and of time in the abstract. This, in a truly masterly manner, whether the fundamental metaphysical assumption of all his strife mechanism between mental elements be in any way warranted or not.

James Mill follows Thomas Brown in denying any difference of essential nature between sensation and perception. He took upon himself the task of removing still more completely the "Psychological Fallacy" of self-consciousness,

from our conceptions of mental processes.[1] Yet Mill was not altogether able to free himself at once from the inbred uses of language, or even from the habits of thought current in his age, and indeed still current in the popular psychology of to-day. If, however, Mill's point of view be borne in mind and his meaning be sought for with any generosity and fairness, psychological truths and subtle suggestions of the profoundest and most far-reaching importance may be found in his writings in germ, if not always fully developed.

Time, memory and personal identity are intimately intertwined; the same fundamental mystery lies at the root of all three. With Herbart and his school Mill distinctly declares that not any and every mental succession will give us a perception either of time-relation, of memory, or of identity: and in close accord with Herbart, he asserts, that *certain proper successive combinations of sensations, their reproductions, and repetitions of these reproductions do alone and of themselves constitute all possible forms of all three.* He says: "Imagination consists of ideas. . . . Memory has in it all that imagination has, but it must also have something more. . . . In memory is not only the idea of the thing remembered, there is also the idea of my having seen it. Now these two, (1) the idea of the thing, (2) the idea of my having seen it, combined, make up, it will not be doubted, the whole of that state of conscience which we call memory. But what is it that we are to understand by what I have called 'the idea of my having seen the object'?" (p. 32d). To clear up this question he supposes a case as follows: "I have one sensation, and then another sensation; call them *A* and *B*, and I recognize them as successive." Then, "the consciousness of the present moment (by law of association) calls up the idea of the consciousness of the preceding moment. The consciousness of the present moment is not abso-

[1] "Analysis of the Phenomena of the Human Mind" (London, 1869) I, p. 235. A pregnant passage in Mill is "The term 'I conceive' has the form of an active verb, and with the form of an active verb, the idea of action is so frequently conjoined that we are rarely able to separate them." Perhaps the chief point of difference in the general systems of Brown and Mill is, that the latter abandons "relations" as a separate element or phenomenon of mind.

lutely simple; for whether I have a sensation or idea, the idea of what I call myself is always inseparably combined with it. The consciousness then of the second of the two moments in the case supposed, is the sensation combined with the idea of myself, which compound I call 'Myself Sentient.' This Self Sentient, in other words, *sensation B combined with the idea of self*, calls up the idea of *sensation A combined with self*. This we call Memory" (p. 337). Memory then, Mill finds to consist of three parts: "the remembering self; the remembered self; and the train which intervened. Of these three parts, the last has been fully expounded. The recalling of the successive states of consciousness, which composed the intervening train, is an ordinary case of association; the other parts, *the two selves*, at the extremes of this train, require further consideration. The self at the first end, is the remembered self; *the self which had a sensation or an idea*. The idea of this self, therefore, consists of two parts: of self, and a sensation or an idea. The last mentioned part of this combination, the sensation or idea, needs no explanation; the first, that which is called self, does. The self at the other extremity of the chain of consciousness, is the *remembering self*. Remembering is associating. The idea of this self, then, is the combination of self with the idea of associating. And here, too, associating needs no explanation; it is the other part of the combination that does. The analysis, then, of self, or the account of what is included in that state of consciousness commonly called the *idea of personal identity*, is still wanting to complete the development of memory" (p. 338). In modern times the associational conception of self, or personal identity, is too well known to need here that long and subtle explanation which Mill in his day found it difficult to express with any sort of comprehension. The self-problem is abstruse and obscure even in our day of "fringes," and of feelings of "ifs, buts and ands." It is not to be wondered, therefore, that Mill's first handling of the subject should contain contradictions and short-comings of the grossest order; but the student who is alive to its full significance will find in Mill's elucidations the traces of a master psychologist.

The gist of Mill's theory, and particularly as applied to time, is, that we do not go outside of our ordinary sensations and their corresponding reproductions, as governed by the natural laws of production, association, and reproduction, in any of the processes of mind whatever; whether of personal identification, memory or perception of time relations.

This view differs from that of Herbart chiefly, in that the elements of sensation are not looked upon by Mill as "reals" between which there is direct attraction and repulsion, a metaphysical assumption for which there is to be found no scientific warrant; and it differs still more from the view of Volkmann in that no secondary feeling or sense of contention in the ordinary mental content, is needed; which secondary order of feeling is itself another metaphysical speculation without scientific justification or support.

JOHN STUART MILL sums up the case against the crucial point of his father as follows: "The distinction between a mere combination of ideas in thought, and one which reveals to us a combination of sensations as actually experienced, always returns on our hands as an ultimate postulate."[1]

But this can scarcely be conceived to be relevant to the position of his father, with whom a series of mental states actually occurring, that is, "a combination of sensations as actually experienced" *was* accepted as an ultimate postulate. The father's endeavor was, this *being* accepted or postulated, to show how the processes of memory worked *under* this postulate. With the elder Mill the ultimate postulate was that "series actually occurred"—out of these he developed the memory and the belief. His son first postulated the belief; the fault of which seems to be the same as postulating any other function, or faculty of the mind before inquiring if that faculty or function cannot be discovered to be a compound process. The "belief" can be deduced from the series, not the series from the "belief." J. S. Mill also went back to and emphasized the English school's theory of relations as taught by Brown.

HERBERT SPENCER'S evolutionary system of realism is well known; it conceives the entire physical world to be devel-

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[1] Ibid. Appendix I, 416.

oped from ultimate homogeneous units, and all consciousness to be a corresponding development of mental units. The salient feature of Mr. Spencer's psychology is his theory of Relations. "The proximate components of mind are of two broadly contrasted kinds: Feelings, and the Relations between feelings. . . . Each feeling, as we here define it, is any portion of consciousness, which occupies a place sufficiently large to give it a perceivable individuality; which has its individuality marked off from adjacent portions of consciousness by qualitative contrasts; and which when introspectively contemplated, appears to be homogeneous . . . A relation between feelings is on the contrary, characterized by occupying no appreciable part of consciousness. Take away the terms which it unites, and it disappears along with them; having no independent place, no individuality of its own. It is true that under an ultimate analysis, what we call a relation proves to be itself a kind of feeling—the momentary feeling accompanying the transition from one conspicuous feeling to an adjacent conspicuous feeling. And it is true that notwithstanding its extreme brevity, its qualitative character is appreciable; for relations are distinguishable from one another, only by the unlikeness of the feelings which accompany the momentary transitions. Each relational feeling may, in fact, be regarded as one of those nervous shocks, which we suspect to be the units of composition of feelings; and though instantaneous, it is known of greater or less strength and as taking place with greater or less facility. But the contrasts between these relational feelings and what we ordinarily call feelings is so strong that we must class them apart."[1] Relations, then, with Mr. Spencer are an entirely disparate sense, as much as the time-sense of Czermak, or the time-feelings of Horwicz. "A succession of changes" Mr. Spencer declares to be "the subject matter of psychology; it is the business of psychology to determine the law of their order." Of particular importance for the time question is Mr. Spencer's fundamental conception of perceptions of likeness and unlikeness of relations of succession.

[1] Principles of Psychology (New York, 1877), I, 163.

"The requisite to the existence of a relation is the existence of two feelings between which it is the link. The requisite to the existence of two feelings is some difference. And therefore the requisite to the existence of a relation is the occurrence of a change, the passage from one apparently uniform state to another apparently uniform state, implying the momentary shock produced by the commencement of a new state."[1] "The ultimate relation therefore, is nothing more than a change in the state of consciousness; and we call it either a relation of unlikeness, or a relation of sequence, according as we think of the *contrast* between the antecedent and consequent states, or of their *order*."[2] Mr Spencer suffers much difficulty with his relations of likeness. "The two terms of a relation of likeness are the antecedent and consequent of what, in one sense, is *no change*; seeing that it leaves consciousness in the same condition as before." But as above, because "two states if not different can not exist as separate . . . accurately speaking, therefore, a relation of likeness consists of two relations of unlikeness which neutralize each other. It is a change from some relatively enduring state A to another state X (which represents the feeling we have while passing from one of the like things to the other) and a change from the transitory state X, to a second relatively enduring state A, which would be indistinguishable from the first state were it not divided from it by the state X" (p. 284). Surely here are contradictions as obvious as print can make them. Yet these are Mr. Spencer's theories of Relations, which he considers the fundamental principle of all reason and all intelligence,[3] including of course all problems of identity, memory and time-perception.

Mr. Spencer's manner of elucidating the latter is, however, more successful, and is perhaps more profound than that of

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[1] Vol. II, p. 287. Query: If a 'shock of relation' intervened between the two like states, would not this suffice, by Mr. Spencer's own theory, for the two states to be known *as* separate and also as like? Again: *Why* may not consciousness be in two states at the same time? Have we any proof that an area of red and an area of blue may *not* be simultaneously in consciousness? Rather this is what apparently does take place.

[2] Ibid.

[3] Ibid, chapters on Reason and Intelligence.

any other writer. This, if his theory of relations be borne in mind, may be sufficiently indicated by saying that it develops from his standpoint of Relations, along the traditional lines of English association (especially of James Mill), perfected and enlarged in accordance with the doctrines of evolution.

S. H. HODGSON, in his "Philosophy of Reflection" (Vol. 1, p. 248-254) has produced a discussion, which deserves a place here, if for nothing more than to sample the loose, irresponsible sort of imagination regarding the subject, that not only gets printed, but also gets quoted. "What I find, when I look at consciousness at all is, that what I can not divest myself of, or not have in consciousness, if I have consciousness at all, is a sequence of different feelings. . . . The simultaneous perception of both sub-feelings, whether as parts of a co-existence or of a sequence, is the total feeling—the minimum of consciousness—and this minimum has duration. . . . Time duration, however, is inseparable from the minimum, notwithstanding that, in an isolated moment we could not tell which part of it came first, which last. . . . . We do not require to know that the sub-feelings come in sequence, first one, then the other; nor to know what coming in sequence means. But we have in an artificially isolated minimum of consciousness, the rudiments of the perception of former and latter in time, in the sub-feeling that grows fainter, and the sub-feeling that grows stronger, and the change between them. . . . In the next place, I remark that the rudiments of memory are involved in the minimum of consciousness. The first beginnings of it appear in that minimum, just as the first beginnings of perception do. As each member of the change or difference which goes to compose that minimum is the rudiment of a single perception, so the priority of one member to the other, although both are given to consciousness in one empirical present moment, is the rudiment of memory. The fact that the minimum of consciousness is difference or change in feelings, is the explanation of memory as well as of single perceptions. A former and a latter are included in the minimum of consciousness; and this is what is meant by saying that all consciousness is in the form of *time*, or that time is the form of

feeling, the form of sensibility. . . . It is clear that the minimum of feeling contains two portions, a sub-feeling that goes and a sub-feeling that comes." Mr. Hodgson seems to mean by "having rudiments of perception," etc., that *alone* which he conceives to take place in a single momentary sequence; and by "knowing how these take place" to mean the long processes of his thought when he thinks *about* the rudimentary process; but why confuse the two so continually? To say that "a former and a latter are included in the minimum of consciousness" is in reality declaring that a former term of a sequence includes a latter term of that sequence.

E. R. CLAY, in his "The Alternative" (p. 167), also adds under title of the "Specious Present" another confusion to the problem. The gist of his view is as follows: "All the changes of place of a meteor seem to the beholder to be contained in the present. At the instant of the termination of such series, no part of the time measured by them seems to be past[1]." Supposing the meteor went on whirling about for an hour, a day, a year or two: there might continue to appear to the observer an unbroken streak of light around the heavens in the path of the meteor, yet would he never discover beside this simple case of visual after-image, certain sensations of motion "going on?" When he did discover the process of this going-on-series would "*all of this series seem to be contained in the present?*" The *continuing* after-image seems confounded by this author with a *remembrance* of the motion series; there is no more justification for confounding the *momentary* after-image with a *momentary* motion series than there would be for confounding a *week* of after-image with the eternal path of the hypothetical meteor.

M. GUYAU, in his "La Genése de l' Idée de Temps (Paris, 1890), from an entirely empirical standpoint, develops the idea of time out of our ideas of space. Every co-existent presentation which constitutes our idea of a series as such, is more or less a figurative presentation; *i. e.*, spatial. Both space and time he traces back to feelings of effort of motion. The will is the present; the desire is the future. M. Guyau

[1] Cited by Prof. James, I, 609.

fairly represents the present tendency of psychology in France.

The article on Psychology in the 9th edition of the *Encyclopædia Britannica*, by JAMES WARD, gives an admirable summary of the best current opinion on psychological matters, save perhaps with too much leaning toward the widely doubted theories of apperception put forth by Prof. Wundt.

Mr. Ward does not attempt metaphysically to go behind the data of psychology: "By pure Ego or Subject it is proposed to denote the simple fact that everything mental is referred to self" (p. 39). Of the origin of this self he says: "The body becomes in fact the earliest datum for our later conceptions of permanence and individuality" (p. 56). He adopts the Laws of Association as stated by Dr. Bain (p. 61) whose classification of the elements of the mind he also accepts, namely: sense, feeling, will (p. 40). This, with the following remark of Mr. Ward regarding the traditional discussion of perception *vs.* sensation, will make his general psychological standpoint sufficiently clear for our purpose: "It has been usual to say that perception implies both memory and imagination; but such a statement can be allowed only as long as these terms are vaguely used" (p. 61).

Approaching the subject of time Mr. Ward says: "Thus as the joint effect of obliviscence and reduplication we are provided with a flow of ideas distinct from the memory-train, and thereby with the material, already more or less organized for intellectual and volitional manipulation" (p. 62). That is for thought in general in distinction from actual remembrances. "Retentiveness is both a biological and a psychological fact; memory is exclusively the latter. In memory there is necessarily some contrast of past and present; in retentiveness nothing but the persistence of the old" (p. 47). "Memory includes recognition; recognition as such does not include memory. . . . But of the two characteristics of memory proper—(*a*) concreteness of circumstantiality, and (*b*) localization in the past—the latter is the most essential" (p. 63). With the content of memory or time-percepts we are not at present concerned; on how this content is localized in the past, Mr. Ward writes as follows: "To a being whose

presentations never passed through the transitions which ours undergo—first divested of the strength and vividness of impressions (original sensations), again reinvested with them and brought back from the faint world of ideas—the sharp contrasts of 'now' and 'then,' and all the manifold emotions they occasion, would be quite unknown. . . . Time-order, succession, antecedence and consequence, of course, there might be still; but in that sense of events as 'past and gone forever' . . there is much more than time-order. . . . We have not to ask how time itself comes to be; but assuming it to be, we ask how the individual comes to know it. . . . . The present, though a point of time, is still such that we can and do in that moment attend to a plurality of presentations, to which we might otherwise have attended severally in successive moments. Granting this implication of similarity and succession, we may, if we represent succession as a line, represent simultaneity as a second line at right-angles to the first; empty time—or time length without time breadth—we may say is a mere abstraction. Now it is with the former line that we have to do in treating of time as it is, and with the latter in treating of our intuition of time, where, just as in perspective representation of distance, we are confined to lines in a plane at right-angles to the actual line of depth. In a succession of events, say of sense impressions A, B, C, D, E. . . . the presence of B means the absence of A and of C; but the presentation of this succession (as a whole) involves the simultaneous presence, in some mode or other, of two or more of the presentations A, B, C, D. In presentation, as we have seen, all that corresponds to the difference of past, present and future, is in consciousness simultaneously. This truism, or paradox, that all we know of succession is but an interpretation of what is really simultaneous or co-existent, we may then concisely express by saying, that we are aware of time only through time-perspective, and experience shows it is a long step from a succession of presentations, to such presentations of succession. The first condition is, that we should have represented together presentations that were in the first instance attended to successively, and this we have both in the

persistence of primary memory-images, and in the simultaneous reproduction of longer and shorter portions of the memory-train. In a series thus secured there may be time-marks, though no time, and by these marks the series must be distinguished from other simultaneous series. To ask which is first among a number of simultaneous presentations is unmeaning; one might be logically prior to another, but in time they are together and priority is excluded. Nevertheless, after each distinct representation a, b, c, d, there probably follows, as has been supposed, some trace of that movement of attention of which we are aware in passing from one presentation to another. In our present reminiscence, we have, it must be allowed, little direct proof of this interposition; though there is strong indirect evidence of it in the tendency of the flow to follow the order in which the presentations were first attended to. With the movements themselves we are familiar enough, though the residua of such movements are not ordinarily conspicuous. These residua, then, are the temporal-signs, and together with the representations connected by them constitute the memory continuum. But temporal signs alone will not furnish all the pictorial exactions of the time perspective. They give us only a fixed series; but the working of obliviscence, by insuring a progressive variation in intensity and distinctness as we pass from one member of the series to the other, yields the effect which we call time-distance. By themselves, such variations would leave us liable to confound more vivid representations in distance, with fainter ones nearer the present, but from this mistake the temporal-signs save us; and as a matter of fact, when the memory-train is imperfect such mistakes continually occur. On the other hand, where these variations are slight and imperceptible, though the memory continuum preserves the order of events intact, we have still no such distinct appreciation of comparative distance in time, as we have nearer the present when these perspective effects are considerable." (pp. 64, 65.)

Two points are to be observed in the above: First, Mr. Ward does not go outside of his three classes of mental elements: Sense, Feeling and Will; does not posit any hypo-

thetical special time-sense, feeling, intuition, concept, self or super-consciousness whatever; and second, he conceives every time-concept to be a complex co-existent state, and not a series of states.

Prof. WILLIAM JAMES devotes a chapter of his vigorous and suggestive Principles of Psychology to the perception of time. In general philosophical standpoint he confesses himself a spiritualist, but he is far from abhorring mechanism in memory and time-perception. He says "objects fade out of consciousness slowly. If the present thought is of A, B, C, D, E, F, G, the next one will be of B, C, D, E, F, G, H, and the one after that of C, D, E, F, G, H, I, the lingerings of the past dropping successively away, and the incomings of the future making up the loss. These lingerings of old objects, these incomings of new, are the germs of memory and expectation, the retrospective, and the prospective sense of time. They give that continuity to consciousness without which it could not be called a stream." (I, p. 606.) "The strict present . . . is in fact, an altogether ideal abstraction. Reflection leads us to the conclusion that it *must* exist, but that it *does* exist can never be a fact of our immediate experience." Prof. James then introduces Mr. Clay's "Specious Present" given above and proceeds—"In short the practically cognized present is no knife edge, but a saddle-back with a certain breadth of its own on which we sit perched, and from which we look in two directions into time. The unit of composition of our perception of time is *a duration*, with a bow and a stern, as it were, a rearward and a forward-looking end. It is only as parts of this *duration-block*, that the relation of *succession* of one end to the other is perceived. We do not first feel one end and then feel the other after it, and from the perception of the succession infer an interval of time between, but we seem to feel the interval of time as a whole, with its two ends imbedded in it. The experience is from the outset a synthetic datum, not a simple one; and to sensible perception its elements are inseparable, although attention looking back may easily decompose the experience and distinguish its beginning from its end. (pp. 608–610.) There is a certain emotional *feeling* accompanying the intervals of

time" (p. 618). "The feeling of time and accent in music, of rhythm, is quite independent of that of melody." (p. 619.) "All continuous sensations are *named* [counted] in beats. We notice that a certain finite 'more' of them is passing or already past . . . the sensation is the measuring tape, the perception the dividing engine which stamps its length. As we listen to a steady sound, we *take it in* in discreet pulses of recognition, calling it successively the same! the same! the same!" "After a small number of beats our impression of the amount becomes quite vague. Our only way of knowing it accurately is by counting, or noticing the clock, or through some other symbolic conception. When the times exceed hours or days, the conception is absolutely symbolic. No one has anything like a *perception* of the greater length of the time between now and the first century than that between now and the tenth. There is properly no comparative time *intuition* in these cases at all. It is but dates and events *representing* time." (p. 622). "The feeling of past is a present feeling." "*A succession of feelings, in and of itself, is not a feeling of succession. And since, to our successive feelings, a feeling of their own succession is added, that must be treated as an additional fact requiring its own special elucidation*" (p. 628). He here introduces approvingly the time-theory of Mr. Ward given above. Then he proceeds "and since we saw a while ago that our maximum distinct *intuition* of duration [specious present] hardly covers more than a dozen seconds, we must suppose that *this amount of duration is pictured fairly steadily in each passing instant of consciousness* by virtue of some fairly constant feature in the brain process to which the consciousness is tied. *This feature of the brain process, whatever it be, must be the cause of our perceiving the fact of time at all.*" "Please observe, however, that the reproduction of an event *after* it has once completely dropped out of the rear ward end of the specious present is an entirely different psychic fact from its direct perception in the specious present as a thing immediately past. A creature might be entirely devoid of *reproductive* memory and yet have the time-sense, but the latter would be limited in his case, to the few seconds immediately passing by. Thus

memory gets strewn with *dated* things dated in the sense of being before or after each other. The date of a thing is a mere relation of *before* or *after* the present thing, or some past or future thing. Some things we date simply by mentally tossing them into the past or future direction. So in space we think of England as simply to the eastward, etc." "But the *original paragon and prototype* of all conceived times is the specious present, the short duration of which we are immediately and incessantly sensible." (pp. 630 sq.) "*Now to what element in the brain-process may this sensibility be due?* It cannot, as we have seen, be due to the mere duration itself of the process; it must be due to an element present at every moment of the process, and this element must bear the same inscrutable sort of relation to its correlative feeling which all other elements of neural activity bear to their psychic products, be the latter what they may" (p. 632). "To state it in neural terms *there is at every moment a cumulation of brain processes overlapping each other, of which the fainter ones are the dying phases of processes which but shortly previous were active in a maximal degree. The amount of the overlapping determines the feeling of the duration occupied. What events shall appear to occupy the duration depends on just what processes the overlapping processes are.*" (p. 635.) "*Why* such an intuition should result from such a combination of brain-processes I do not pretend to say. All I aim at is to state the most *elemental* form of the psycho-physical conjunction." (p. 636.) "Longer times are conceived by adding, shorter ones by dividing portions of this vaguely bounded unit [specious present] and are habitually thought by us symbolically. Kant's notion of an *intuition* of objective time as an infinite necessary continuum has nothing to support it." (p. 642.)

Prof. James then passes to the consideration of memory: "*It is the knowledge* of an event, or fact . . . with the additional consciousness that we have thought or expressed it before." "No memory is involved in the mere fact of recurrence. The successive editions of a feeling are so many independent events, each snug in its own skin . . . . . Memory requires more than mere dating of a fact in the past.

It must be dated in *my* past" . . . "A general feeling of the past direction in time, then, a particular date conceived as lying along that direction, and defined by its name or phenomenal contents, an event imagined as located therein, and owned as part of my experience—such are the elements of every act of memory" (p. 650). "Memory is then the feeling of belief in a peculiar complex object; but all the elements of this object may be known to other states of belief; nor is there in the particular combination of them as they appear in memory anything so peculiar as to lead us to oppose the latter to other sorts of thought as something altogether *sui generis* needing a special faculty to account for it. When later we come to our chapter on belief we shall see that any represented object which is connected either mediately or immediately, with our present sensations or emotional activities tends to be believed in as a reality. The sense of a peculiar active relation in it to ourselves is what gives to an object the characteristic quality of reality, and a merely imagined past event differs from a recollected one only in the absence of this peculiar feeling relation. The electric current, so to speak, between it and our present self does not close. But in their other determination the recollected past and the imaginary past may be much the same. In other words, there is nothing unique in the *object* of memory, and no special faculty is needed to account for its formation." (p. 652).

Thus Prof. James' time-sense is a separate disparate feeling, like that of Horwicz, Czermak, *et al.* But do we have any such extra feelings? How could any such extra feeling be other than just another feeling as separate as all the rest? How could it join these overlapped feelings any more than they could join themselves—or than merely successive feelings could join themselves? Who is it that sits in the saddle-back and looks both ways? How does this Jack-in-the-saddle *know* which way to look; *which way* the overlapping feelings are overlapped? which way they *are* moving? *How does this feeling know or constitute anything regarding time direction, more or other than the passing sequence constitutes of itself?*

Casting an eye backward, we can but be struck by the wide variety of explanations offered for the time-mystery. Time has been called an act of mind, of reason, of perception, of intuition, of sense, of memory, of will, of all possible compounds and compositions to be made up from all of them. It has been deemed a General Sense accompanying all mental content in a manner similar to that conceived of pain and pleasure. It has been assigned as a separate, special, disparate sense, to nigh a dozen kinds of "feeling," some familiar, some strangely invented for the difficulty. It has been explained by "relations," by "ear-marks," by "signs," by "remnants," by "struggles" and by "strifes," by "luminous trains," by "blocks of specious-present," by "apperception." It has been declared *à priori*, innate, intuitive, empirical, mechanical. It has been deduced from within and from without, from heaven, and from earth, and from several things difficult to imagine as of either. Finally, one high modern authority has discovered that time is the long-sought-for fourth dimension of space. In one particular alone is there uniformity; with the exception of Condillac, James Mill, Herbart, and Horwicz, *all* have looked upon the mystery unqualifiedly and unmistakably as *a single state*. Among the best modern authorities the presentation of time-order and relation may be said to have worked itself out to what, though expressly declared to be otherwise, is really a sort of compromise position between a simple state and a simple *process*; to be looked upon as a certain definite, particular, complex, though co-existent *arrangement*. It is the most striking feature of the whole time investigation, that of all the philosophers and psychologists who have touched upon the problem, only *two* of the whole number, Condillac obscurely, and James Mill definitely, have solved the mystery by *letting the sequences themselves be the ultimate mystery*—by letting their process, as process and of itself, show forth its own explanation. It would not be surprising if such diversity of failures should be explained by such unity of neglect of careful and exhaustive consideration of this seemingly most natural and certainly most simple source of explanation. A further examination of this point will constitute a later section of this paper.

II.—EXPERIMENTAL INVESTIGATIONS.

The earliest empirical observation which I find recorded is otherwise unimportant. The Scotch philosopher, THOMAS REID, says: "I have found by some experiments that a man may beat seconds for one minute without varying above one second in the whole sixty; and I doubt not but by long practice he might do it still more accurately. From this I think it follows that the sixtieth part of a second of time is discernible by the human mind."[1]

As the philosophy of time has usually followed that of space, so experiments upon it were an outgrowth of those on space.

In 1852 E. H. WEBER published his famous discoveries regarding our appreciation of distance and direction on the surface of the body. That this appreciation varied without proportion to our sensitiveness to pressure or temperature for the same regions, Weber held as proof that our space perceptions were made by a strictly disparate sense, which, coining the phrase, he called the space-sense.[2]

JOH. NEP. CZERMAK, professor of physiology at Leipzig, perceived that these views necessarily involved our conceptions of time; he was, therefore, led to believe in still another disparate sense, which he named the time-sense.[3] As this invariably accompanied all other sensations, he termed it a general sense in distinction from the special senses. Unable to carry out his intentions he recommended the following to be determined: (1) The shortest interval perceivable in each of the separate senses. (2) How the same interval is interpreted by the different senses. (3) How like rates of motion are interpreted by various regions of the skin, determined by Weber to be of different spatial sensibility. (4) The least change

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[1] Complete Works (Edinburgh, 1872), p. 350.

[2] "Ueber d. Raumsinn u. d. Empfindungskreise in d. Haut u. d. Auge." D. könig. Säch. Gesell. d. Wiss. zu Leipzig. Sittung 18, Dec., 1852. Math. Phys. Classe, 1-4, Jahrgang, 1849-52, S. 85.

[3] "Ideen zu einer Lehre von Zeitsinn." Complete works (Leipzig, 1879); also Wiener akadem. Sitzungsberichte, 1857; Nat. Cl. Bd. XXIV, p. 231; and Moleschott's Untersuch., Bd. V, Heft. 1, 1858.

in rate of motion perceivable for various dermal regions. (5) The relations between rates of motion and changes in the angle of convergence of the eyes. (6) To investigate the formula $V = \frac{r}{t}$ for points of the retina or skin having different spatial sensibility (V, rate of motion; r, space; t, time). Some of the suggestions of Czermak, by reason of his high standing as a physiologist, were immediately undertaken. Nearly at the same time Vierordt, assisted by Höring and Camerer at Tübingen, and Mach at Graz, began the work.[1]

A. Höring. *Versuche über das Unterscheidungsvermögen des Hörsinnes für die Zeitgrössen.* Inaug. Dissertation, Tübingen, 1864.

Experiments: Eight beats were given by a Mälzel metronome; then without appreciable loss of time the weight was moved up or down or left as before. Subject without having seen the pendulum, was to judge if the second set of beats be "longer," "shorter," or "same" in comparison with the first set; the cases in which the subject was unable to decide were thrown out of the records. The experiments were made on Höring by Prof. Vierordt. A total of 1,885 sets of beats were taken, using intervals from .306 to 1.428 in length;[2] an average of 10 trials was made for each interval, and 82 was the maximum for any interval. The experiments were delayed through a half year to avoid fatigue and any unusual influences. The method used was that of Right and Wrong Cases.

Results: A constant inclination to misjudge the second or compared set of intervals; intervals of .454–1.428 were estimated to be shorter, and those of .306 to .365 longer than they were. Sensibility or discrimination decreases with lengthening of the interval.

Comment: No ordinary metronome is sufficiently accurate for this purpose; as it runs down, the strength of tick and length of beat varies; alternate beats can not be maintained of equal length; the weight can not be accurately adjusted without varying the interval between the first and second set of

[1] It has seemed best in what follows to vary from the continuous narrative form of presentation toward that employed in the review department of the Journal of Psychology. Abstracts of contributions to the subject will be distinguished from my own comment by a different typography.

[2] In all cases not otherwise specified the unit is a second.

beats, which is important. Too few trials were made on each interval to warrant the conclusion that the results were more than mathematically fortuitous. Only one person was experimented upon, while contradictory individual differences are the rule. The results regarding sensibility have been confirmed; those as to the constant error have been variously confirmed and contradicted.

WILHELM CAMERER. *Versuche über den zeitlichen Verlauf der Willensbewegung.* Inaug. Diss. Tübingen, 1866. Zeitschrift für Biologie, Bd. XVII; S. 17.

Results: It was found that movements made in 1.5 could be adjusted to cover the distances tested with greatest accuracy; the hand attempting to measure off a given distance in a shorter or longer time, respectively, over-ran or fell short of the proper distance.

ERNST MACH. *Untersuchen über den Zeitsinn des Ohres.* Moleschott's Untersuchungen, 1866, Bd. X; S. 181; and Sitz. d. Wiener Akad. d. Wiss. Math. Kl. Bd. 51; Abth. 2, 1865.

Standpoint: Herbartian; and the time-sense looked upon as disparate. *Purpose:* To test Weber's law. *Apparatus:* Finely adjusted metronome, beating alternately long and short beats or the reverse. For very short intervals a spring was used, snapping upon teeth cut at iambic intervals upon the edge of a wheel which was revolved by hand mechanism. For very long intervals the assistant held a watch to the ear and beat with a hammer. *The method* used was Least Perceivable Difference. *Experiments* extended from year 1860 to 1865; it is indefinitely stated that "a great number of trials" were made upon six persons, using intervals from .016 upward. *Results:* Weber's law not valid. Sensibility inverse to length of interval, and varies daily; greatest sensibility shown for intervals of about .375. Threshold (for ear) about .016, and less for ear than for any other of the senses. When iambic intervals are repeated many times in same direction, we lose power to distinguish the longer from the shorter beat; this effect is counteracted by alternating the directions.

Comment: Turning a wheel, and beating with a hammer by the hand, can not give accurate results. The number of trials is not stated, and figures are given for but a few of the intervals tested. The paper is too indefinite to justify its results. The threshold found is far higher than subsequent experiments have established.

KARL VIERORDT. *Der Zeitsinn.* Tübingen, 1868.

Standpoint: Time perception is rather an act of judgment than of sense; "the soul is needed to explain many things." *Purpose:* To investigate the time-sense in general and the constant error in particular. *Apparatus:* Same as used by Camerer and Höring; also kymograph and a writing lever, one arm of which wrote directly on the drum, the other arm being worked by the finger. *Method:* Chiefly that of Right and Wrong Cases; asserts it was used in his laboratory as early as 1853. *Experiments:* (1) Two ticks of the metronome, self-recorded on the kymograph, were given by the assistant; the subject then pressed his finger to mark off on the drum an interval immediately following and equal to that given by the metronome. (2) Another set of experiments was like the above save that a pause, whose length was determined by the subject, was made between the normal or metronome interval and its reproduction. (3) Eight successive beats were given from the metronome, the subject immediately recording a like number of judgments. (4) Beats were given by touch on the back of the left-hand with a small steel point; two beats. pause, followed by single reproduction with right-hand as in (2); eyes and ears closed. (5) Subject chose any interval at random, and tried to record three beats inclosing two equal intervals. (6) Four beats in place of three, a pause being introduced between first and last interval as in (2). (7) Interval chosen at will as in (5), then reproduced from 4 to 120 times (generally about 4 reproductions). (8) Seven classes of judgments were made, namely: Very long, long, tolerably long, indifferent, tolerably short, short, very short; attendant then gave an interval repeating it 10 times, and the subject assigned it to one of the above rubrics. (9) Estimation of longer intervals, *i. e.*, from 5 min. to an hour. (10) Experiments with intervals of sight.

Results: "For all categories of time from seconds to years, the same law holds good, *i. e.*, the relatively short intervals are lengthened by judgment and the relatively long intervals are shortened." Vierordt holds his experiments sufficient to determine the law definitely, though the constant error may vary for different persons, times of experiment, senses, and other conditions. He tested intervals usually ranging from .25 to about 8. The indifference point for himself was: ear, 3 — 3.5; eye, 2.2 — 2.5, for H. (ear) 1.4; for N. 1.5. The indifference point fell on a longer interval when a pause was made between norm and reproduction. Morning hours, and good physical and mental condition were favorable to more accurate estimates of longer intervals; intense mental strain led to under-valuation. Sensibility was found greatest at about 1 to 1.5, and was more exact when as in (1) no pause

was made between norm and judgment. Judgment was more accurate after 8 beats as in (3), than when the norm was heard but once. Weber's law does not hold. Vierordt suggests that contrasts affect judgment; that after several short beats, a longer interval seems unduly long.

Comment: Only three persons were experimented upon; most of the results are from two individuals; 2147 single judgments were made in all; these spread over the large number of intervals tested, under several different methods, and upon two men, leaves far too few trials on any one interval, for conclusive results. The same criticism of metronomes applies here as to Höring. The results are valuable as far as they go, but must be deemed inconclusive even on the points taken up.

WILHELM WUNDT. *Ueber psychologische Methoden.* Wundt's Phil. Studien. Bd. I. 1882; S. 1.

Wundt here complains that Vierordt's experiments unwarrantably complicate the time judgments with voluntary muscular movements; that is those used in reproduction; also that the indefinite pause introduced between the norm and the reproduction in many of the experiments causes an indefinite break in the rhythm, which must disturb judgment with great irregularity. Wundt claims that the time-sense is so extremely delicate that the apparatus used by Vierordt as well as his method of Right and Wrong Cases, can give no reliable results. Wundt recommends his own method of Least Perceivable Difference.

JULIUS KOLLERT. *Untersuchungen über den Zeitsinn.* Wundt's Phil. Studien. Bd. I. 1882; S. 78.

This work was done under the direction of Prof. Wundt at Leipzig. *Purpose:* To reinvestigate the Constant Error and Sensibility, with more accurate apparatus and method, and particularly without involving the time-reaction of reproduction. *Apparatus:* Two finely adjusted metronomes, governed by electric current and magnets. *Experiment:* In all cases the norm was given by two beats from one metronome, then, after a pause invariably equal to the norm, another interval was given by two beats from the other metronome; these two intervals to be judged according to Wundt's method of Least Perceivable Difference, that is, the compared interval was first made equal to the norm, then gradually lengthened till it was just perceived to be longer than the norm; next the compared interval was made marked-

ly longer then the norm, then gradually shorter till just indistinguishable from the norm; the average was then taken of these two judgments just perceivably longer than the norm. An average is similarly determined for the two judgments just perceivably shorter than the norm. The Constant Error is then calculated by averaging the just perceivable shorter and longer judgments so determined. The norms used were .4, .5, .7, .8, 1.0, 1.2, and 1.836. Seven men were experimented on, and a total of 175 single determinations of the Constant Error made.

Results: 42 or about 25% of the 175 determinations were classed apart as "anomalies" because in these the Constant Error appeared a maximum at the point where in the "regular" cases it appeared a minimum. The remaining 133 "regular" trials confirmed Vierordt's Law that for relatively long intervals the Constant Error is negative, and for relatively short ones positive; but the Indifference Point as averaged from the seven persons was .755 in place of 3. — 3.5 as given by that experimenter. The 42 anomalous trials were mostly overjudged. Sensibility was greatest at the Indifference Point, diminished rapidly with shortening intervals, and more slowly with lengthening intervals. No explanation was found for the "anomalies."

Comment: Metronomes have never proved sufficiently accurate or reliable for time experiments; to use two metronomes together is objectionable as the difference of their sound disturbs judgment. It is doubtful if Wundt's method of Least Perceivable Difference as used by Kollert is free from objections, since the judgment of the subject is always biased; he knows beforehand the direction and nearly the degree in which his judgment is to be made, *i. e.* which way the pendulum weight is to be moved and about how much, and soon *expects* to perceive no difference or the reverse. There seems no good reason for having culled out the 42 anomalies; that they were different from what was expected is no ground for classifying them apart. The remaining 133 trials, when divided among seven persons, and again among the seven intervals used, leaves but an average of about 3 trials for each interval per man, which, in view of the great variation the time-problem is now known to be susceptible to, is altogether insufficient to prove the results to be more than mathematically fortuitous. Kollert lumps his results leaving us entirely in the dark as to just how the trials were

divided among men and intervals with reference to specific results. This is inexcusable and, besides detracting largely from the value of his own conclusions, renders impossible any revision of them by a closer analysis of the facts. Care does not seem to have been taken that the subject should remain ignorant both of the course and of the purpose of the experiments; this is important, as otherwise subjective influences are inevitable to a degree that renders the results comparatively worthless. On the whole Kollert's determinations are unsatisfactory and of doubtful value. They show intervals between .755 and 1.836 to be shortened while Vierordt found the same to be lengthened.

KARL VIERORDT. *Psychophysiche Bemerkungen.* Zeitschrift für Biologie, Bd. 18, 1882; S. 397.

Vierordt here briefly defends his work against the attacks of Wundt and Kollert; shows the reaction-time of reproduction is too short to vitiate his results, and that in most of his experiments it was neutralized and not included at all. The pause between norm and reproduction made in some of the rubrics, he thinks most accurately adjusts itself when left to the inclination of the subject. In turn he criticises rather bitterly the method of Wundt, raising many of the objections we have stated above against Kollert.

VOLKMAR ESTEL. *Neue Versuche über den Zeitsinn.* Wundt's Phil. Studien, II. 1884; 37.

This work was also from Prof. Wundt's Laboratory. *Purpose:* To extend the investigations of Kollert, to the longest intervals that can be judged as a whole, and to settle the dispute with Vierordt as to the effect of a pause between norm and comparison. *Apparatus:* New electric machine designed by Prof. Wundt; has horizontal metal wheel graduated on the edge; revolved by weight. Electric connections made at proper arcs of the revolving wheel regulate the desired lengths of norm, pause and comparison intervals; the stroke was made by electric hammer, during some of the experiments, on a bell, during others on an iron anvil. *Method:* Least Perceivable Difference as described of Kollert. *Experiments:* Divided into two sets, one without and the other with a pause, equal to norm, between norm and comparison interval. The intervals investigated were about the same for both sets and ranged from 1.5 to 8. The longer intervals were practised over several times, till they seemed familiar,

and then judged; the shorter intervals, as with all of Kollert's, were judged, each after a single hearing. Ten persons were experimented on, through a range of 18 intervals, with a total of 96 trials in the first set, and 293 trials in the second set.

Results: No time difference appeared between use of stroke of bell and stroke of anvil. Twenty-seven of the ninety-six trials in the first set, and 182 of the 293 in the second set, were culled out as anomalous, on the ground that "purely psychic" phenomena betrayed themselves in these; claimed by Estel to be due to "contrast," that is—all these anomalies were asserted to have occurred in the later experiments of each day, and to vary according as the intervals used during the first part of the day were longer or shorter than those of the later part. Estel stated the Law of Contrasts to be that the hearing of any interval makes a subsequent shorter or longer interval to be judged respectively longer or shorter than it really is. The other important result claimed by Estel was, that while all intervals longer than Kollert's indifference point of .755 "were under-estimated, yet the increase of the Constant Error was not regularly progressive with the lengthening of the interval, but rhythmic; relatively minimal values were asserted to appear at all multiples of the said indifference interval, *i.e* nearly at 1.5, 2.25, 3, 3.75, and 4.5." Sensibility also was rhythmically inverse to the constant error. Weber's Law was declared not to hold. Wundt and Estel incline to the belief that the multiple indifference point is governed by the pendulum-swing of the leg.

Comment: After carefully studying the tables of Estel, we agree with the strictures of Fechner (below) upon the demonstrations of a periodic course of the Constant Error. From the nature of the case irregularities are to be expected, and the assertion that these variations were in any sense rhythmic multiples of the indifference point seems to us entirely unfounded and forced. Also the Law of Contrasts, though perhaps true under very different conditions of quite other significance, seems quite unsupported by the data presented; at least, sufficient of the protocol should have been given to establish the order of the length of intervals used for each day's work. As it is, nothing appears upon which a revision of the facts can be based definitely to disprove Estel's claim—much less to support it.

As a whole the work of Estel appears not only inconclusive, but unscientific; too few trials were made in

proportion to the great variability of the results; only 389 tests were made in all, these divided among ten persons and eighteen intervals each, leave an average of but about two trials for each interval per individual; this is insufficient, particularly when as in the major rubric 209 out of 389 tests are classed apart as "anomalous." Again the "subjective" conditions were not sufficiently guarded. The controversy with Vierordt, under which the work was undertaken was spirited and unfortunate for unbiased psychological judgments; yet no care seems to have been taken to provide subjects undoubtedly free from the subtle involuntary prepossessions, which are so difficult to exclude in all psychological investigations. For such results to be of any definite value, a sufficient number of persons must be experimented upon who know neither the purpose nor the results of their judgments—this in order to establish the testimony beyond even any possible involuntary prejudice. Finally it seems almost incredible in the face of the contradictory evidence of Mach, Höring and Vierordt, and solely upon the meagre and much criticised results of Kollert, reinforced alone by the yet entirely problematical "leg-swing" theory,[1] that Estel should have *assumed* the fundamental Indifference Point upon which he based his entire periodic deductions, without adequate experiment for any of his ten subjects and absolutely with none at all covering that important interval for seven out of the total ten persons. Such neglect can be more easily explained by subjective prepossessions for theories than the results can be admitted to the rank of scientific facts.

G. Theo. Fechner. *Ueber die Frage des Weber'schen Gesetzes und Periodicitätsgesetzes im Gebiet des Zeitsinns.* Ab. d. k. S. G. d. Wis. XIII, S. 3.

This paper subjects Estel's work to long and minute criticism, finally characterizing it as unreliable and false. The variations claimed by Estel as rhythmic, Fechner shows to lie entirely within the probabilities of accidental irregularity. Fechner also considers that nothing is to be dis-

[1] Martin Trautscholdt, in W. and E. Weber, Mechanik d. Mensch. Gewerkzeuge, pp. 77–254; Wundt's Phil. Studien I, 213 (249); Ibid. II, 286, 250.

covered irreconcilable with Weber's Law. Such high authority would have greater weight were the spirit displayed here less controversial, and less enthusiastic for the support of Weber's Law.

VOLKMAR ESTEL. *Ueber die Frage des Weber'schen Gesetzes und Periodicitätsgesetzes im Gebiet des Zeitsinns.* In Wundt's Phil. Studien, II, 1884; S. 475.

Estel makes a weak reply to Fechner's attack. In answer to a request for the precise order of each day's experiments, Estel says the results were unexpected, and the protocol had been designed for other ends, and therefore data could not be given. He excuses the small number of his tests by declaring that he had looked upon them only as indicative, and needing confirmation—that he made as many and on as many persons as "he had time for." As to the charge that he had brought out his results to suit his own preconceptions, he declares they were entirely unsuspected until after the experiments had been performed. His counter criticism against Fechner's deductions from his (Estel's) work in support of Weber's Law is effective.

MAX. MEHNER. *Zur Lehre vom Zeitsinn.* Wundt's Studien, II, 1884, 546.

Purpose: The severe criticisms of Fechner compel a reinvestigation of the work of Kollert and Estel. *Apparatus* and *Method:* The same as Estel's. *Experiments:* The order of each day's work was arranged to be free of all influences of contrasts. No pause was ever permitted between norm and comparison intervals. Judgment was always made after each hearing of the two intervals. Ten determinations were made for each length of interval used; twenty-eight intervals were tested ranging from .7 to 12.1. Mehner was himself subject for all experiments made.

Results: Four Indifference Points were found, namely, .71, 2.15, 3.55 and 5. All the *odd* multiples of the lowest Indifference Point, .71, were shown to be points of minimal worth of constant error, while *even* multiples showed maximal worth. All intervals between .71 and 5 were declared to be under-estimated; all from 5 to 12.1 and "probably far above" to be over-estimated. Sensibility was also a function of the odd multiples of the Indifference Point .71, (though inversely to the constant error) up to 7.1 above which it remained approximately constant; it was greatest at 2.15. Weber's Law did not hold below 7.1, *i. e.* so long as sensibility is rhythmic, but was approximately valid above 7.1, *i. e.* where sensibility is constant. He attributes individual differences and the

great disparity of results obtained by different experimenters mainly to the insufficient and varying amounts of practice which they had in estimating time intervals; he thinks the effect of practice is to lessen the constant error. Straining of the attention makes the interval seem longer; the experienced subject judges with less strain, therefore makes a smaller error; also familiar intervals being judged without a strain are shortened, while the longer ones, requiring great attention, are lengthened. Fatigue and low condition, mental or physical, require greater attention and therefore lengthen the interval; all this accords with and explains his results. Upon these grounds he thinks the results of Estel and others may be reconciled with his own work and with his theory of odd multiple periods, or expressed differently he thinks most of the results previous to his own to be of comparatively little worth, as their experimenters had not attained sufficient experience and skill to bring their judgments up to a non-fortuitous or non-variable standard. Mehner found 12.1 to be the longest interval he could judge without division, instead of the limit of 5—6 determined by Estel; he also attributes this to his greater experience. Mehner determined, contrary to the expectations of Fechner, that it made no difference in the result whether, in comparing the intervals, the long or the short interval preceded the other. He found Estel's Law of Contrasts was without validity for his judgments, where the norm was always heard only once, or at most only a few times; and he even inclines to think that were the norm heard many times and deeply impressed upon the subject, the results would be opposite to Estel's Law, for example, were the norm a short interval, a tendency to preserve this accustomed length would hold over and tend to make a new, subsequent, longer interval seem unduly short. He inclines to favor the method of Right and Wrong Cases as the most accurate and direct. Mehner attributes the alleged phenomenon of Periodicity to a universal rhythmic law, towards which the membering or compounding of all our presentations and mental content tends in general.

Comment: Mehner's experiments were conducted upon a single subject, and that person himself; they could not therefore be held to be general, or even valid for most individuals, until corroborated by many other experiments; also, for this reason they suffer greatly from the liability of subjective prepossessions, as we have explained in the case of Estel. Otherwise his work seems to have been conducted with particular care, and the number of his tests to have been suffi-

cient for establishing the general tendencies peculiar to a single individual. His deductions from these results regarding Periodicity seem, however, as forced and far-fetched as those of Estel, with which they conflict, and which have been severely criticized by Fechner. Re-examining Mehner's tables we believe his Law of Periodicity to be unwarranted by his own figures; there are few columns of figures in which a prepossessed imagination cannot discover some sort of approximate periodicity of equal validity as a "law" with that of Estel or Mehner. Regarding Mehner's opinion that experience, practice and attention explain all the discrepancies in the results of time-experiments, there is so far no adequate information as to what the tendencies of any of these influences are; several investigations regarding mental fatigue, as those of Glass, Cattell, and others in the Physiological Laboratory of this University, fail to support Mehner's view.

G. Theo. Fechner. *In Sachen des Zeitsinnes und der Methode der richtigen und falschen Fälle, gegen Estel und Lorenz.* Wundt's Studien, III, (1884), 1.

Still further criticism is here raised against Estel and Mehner; though Fechner devotes more space to Estel, he seems to hold even weightier objection to the results of Mehner; he thinks the probability of any Law of Periodicity to be negatived by the fact that the law claimed by one contradicts that of the other.

Richard Glass. *Kritisches und Experimentelles über den Zeitsinn.* Wundt's Studien, IV, (1887), 423.

Purpose: Glass assisted Mehner in most of his experiments; his testimony regarding them is therefore of value; he subjects Mehner's figures to a searching scrutiny, and comes to a like conclusion with Fechner; he thinks a proper interpretation of the tables of Mehner even contradicts the Law of Periodicity deduced from them by their author. Glass, therefore, proposes to give the entire matter experimental revision. *Method:* The Method of Average Error is now chosen for the first time in Wundt's Laboratory. *Apparatus:* same as that used by Estel and Mehner, so modified as to be instantly stopped by the operator. *Experiments:* All were made with single norm and single reproductions, and without pause between norm and reproduction. The subject recorded his reproductions or judgments directly by pressing a lever which stopped the revolution of the

wheel; the interval thus recorded was then read from the graduated arc of the wheel. One hundred trials were made on each interval tested; the Constant Error was averaged from these; the intervals asserted by Mehner to be periodic, were those chiefly investigated. Glass was the sole subject for all his work.

Results: Table I comprises 100 trials each, upon twenty-three intervals ranging from .7 to 15.; for all these the Constant Error was negative, with the exception of .7, for which it was slightly positive. Neither Estel's nor Mehner's Periodicity held good, but a new law, based upon multiples of 1.25 was thought to be observed. Therefore, a greater number of intervals, 42 in all, differing less from each other, but covering the same range as the others, was next tested, with 100 trials each. These form Table II, which shows the Constant Error positive for 1.8 and under; negative for 5.4 and over, and variable between 1.8 and 5.4. Periodicity was again thought to be observed on intervals still 1.25 *apart*, but not falling on the *same* intervals as previously. Hence, the experiments given in Table III were undertaken, comprising 100 trials each, on intervals regularly .25 different in length, through the range .75—9, making 34 intervals in all. These showed Constant Error positive for 2 and under, negative for 4 and over; inconstant from 2 to 4. If for Table III, however, a reaction-time of .05 be deducted for the time occupied in stopping the instrument, the Constant Error would be negative throughout except for the lowest interval, .75. Glass concludes that the Constant Error is normally negative for all intervals. Again, all multiples of 1.25 appear as points of relatively minimum values for the Constant Error. The experiments of Table IV were then undertaken to discover the variations in judgment of the same interval from day to day. Only *one* interval and *two* successive days were tested. Glass claims the results "agree pretty well" with each other, and with those for the same interval in Table III. [According to his figures, however, the value from Table I is about 300 per cent. longer; from Table II about 200 per cent. longer; and from Table III about 60 per cent. shorter than those of Table IV.] He, therefore, concludes that in general the variations in his three main tables are not greater than those to be expected from day to day; and in view of their general agreement, so demonstrated, he asserts a new Law of Periodicity striking the multiples of 1.25, though the interval of 1.25 is not itself a point of least value of the Constant Error.

Comment: All the objections which have been made against Mehner for testing his experiments solely upon himself are

applicable with greater force against Glass; for, having assisted Mehner in the previous experiments, he was more liable to have formed prepossessing conceptions. Regarding this third Law of Periodicity, which contradicts the two previously published, a close examination of the tables seems to confirm the views of Fechner, twice maintained by him against the probability of such a law. The insufficiency of the evidence with the fact that each experimenter found a different law entirely irreconcilable with the others, and coupled with the tendency already mentioned, for all columns of figures to present variations more or less delusively or fortuitously rhythmic, ought to dispose of this subject until some very conclusive results shall newly establish such a Periodicity as a fact.

LEWIS T. STEVENS. *On the Time-Sense.* Mind. Vol. XI. No. 43.

These experiments were chiefly performed under the direction of Pres. G. Stanley Hall, at Johns Hopkins University, and were confirmed by other experiments under Prof. Henry P. Bowditch of the Harvard Medical School. *Purpose:* To investigate the Constant Error with both norm and reproduction many times successively repeated. *Apparatus:* Beats were given by a metronome, and recorded by electric circuit on a Marey kymograph; the key of the circuit was extremely delicate, and worked by the finger with scarcely perceptible exertion; the intervals were measured on the drum by a tuning-fork of known vibration rate. *Method:* Average Error. *Experiments:* "The individual under experiment tapped the lever synchronously with the beats of a metronome. When he had become perfectly familiar with the given interval, the drum of the kymograph was set in motion, and the first round of the tracing (the drum worked continuously on a spiral) was taken with the metronome still beating; the latter was then stopped, while the person kept on tapping the lever at the same rate for a period of one minute." The tables show the averaged reproductions for each five seconds. The total number of experiments is uncertainly stated; only one result "showing an average amount of variation" is published for each interval of each individual; tests were made upon seven persons.

Results: One hundred and fourteen out of 135 trials "point to the fundamental principle: That there is an interval of time, the value of which varies between .53 and .87, which

can be reproduced with considerable accuracy; but with all other intervals an error is made, which is plus for those above and minus for those below the so-called indifference point." The average Indifference Point was .71. The Constant Error was found gradually to increase as the Indifference Point was moved away from, in either direction. Twenty-one out of the 135 experiments were classed apart as irregular. "The irregularities consist in reproducing accurately long, in shortening long, and in lengthening short intervals." "The examination of such experiments, however, revealed the fact that the effect of fatigue is to make the error for short intervals *plus* instead of minus, and to increase the amount of variation made in the reproduction of long intervals; and that individuals under experiment are apt, when inattentive, to shorten long and prolong short intervals." "Diversion of attention and small experience are regarded as the cause of the great irregularities" shown in all the experiments.

As to the Law of Periodicity, "two remarkable points are revealed in the manner of variation of the curves. (1) The constant zig-zag of individual records; only in nineteen cases out of 140 were two sequent variations in the same direction. This would seem to indicate that an interval is judged more correctly after it is completed than before, and that correction is made for its error in the next reproduction, according to a standard which the mind carries, but to which the hand (or perhaps the will during the interval) cannot be accurately true. The origin of this peculiarity, therefore, appears to lie not in the judgment, but in the execution. (2) In all of the curves plotted, there were observed more or less distinctly, still larger and more primary waves. The prominence of these varied greatly; in some of the curves they were apparently absent, in others they were decidedly marked. These waves were no more prominent for one interval than for another—their length varies in the majority of cases between .6 and .9 min. and averages .73 min. This rhythmical variation seems not to be in the execution, but rather to have its origin in a rhythmical variation of the standard carried in the mind. That this is connected with the rhythmical changes in the nutritive condition of the cerebral centres, or produced by the vaso-motor rhythmical constriction of arterioles, it would be rash to deny or affirm or perhaps even to suppose."

Mr. Stevens refrains from any opinion as to the contradictions between his own and nearly all previous results, but suggest that these may be due to fundamental differences between single and successive reproductions.

Comment: As published, the number of experiments seems too few to establish conclusive results, as individual

differences and variations from general physical conditions are now known to be great. Also it is doubtful if the metronome used preserved alternate beats of equal lengths through the entire running down of its spring. On the whole, however, this paper is of marked value and reliability.

MICHAEL EJNER. *Experimentelle Studien über den Zeitsinn.* Inaugural Dissertation No. 137, Dorpat, April 18, 1889, under Prof. Kraepelin.

Purpose: To investigate (1) how we judge filled intervals of time. (2) What is the influence of fatigue and practice; (3) pathological disturbances. *Apparatus:* Stop-watch measuring .2 sec. *Method:* Average Error. *Experiments:* Both single and multiple reproductions were investigated; the norm was never heard but once; the assistant called "now" at the beginning and at the end of the norm; the subject announced his judgment by a signal; the length of the norm and reproductions were read from the watch by the assistant; reaction times of both subject and assistant were involved with other slight inaccuracies, but these compensated each other to a degree, and their sum was small in proportion to the unusually long intervals worked with. These were five in number, as follows: 30, 60, 120, 180, 240 seconds. The experiments were extended from Aug. 29th to December 13th, 1889, lasting one hour each day; the single reproduction was always at the same hour of the day. Ejner was the sole subject for his chief tables. For the class of multiple reproductions the judgment was always repeated twenty-five successive times; then the same norm was given again and another set of twenty-five reproductions made; for very long intervals a rest of about a half-hour was made between these two sets. Ten double sets of twenty-five reproductions each, were made by Ejner for each of the five intervals; these multiple reproductions were confined to no particular hour daily. To test individual differences, ten double sets like the above were tested upon two *commilitionen* for the interval 5, and six double sets for 240. For the pathological experiments three patients were selected from the clinique, all of them students. To investigate the effects of attention, 200 single trials each were made upon Ejner for the intervals 30 and 240, under each of the following conditions: (1) Same as his single reproductions above, except that he listened closely to an extra metronome (beating 200 strokes per minute) at the same time that he listened to the norm and made his judgments; (2) While performing mathematical problems.

Results: The tables are admirably arranged, particularly those which compare with each other the average progress of the double sets, for the purpose of showing the effects of fatigue and practice manifested between the two. The main results are as follows. (1) For single reproductions the Constant Error is always negative; for the multiple reproductions it is positive; in both cases it is a maximum at about 120. (2) The Average Error is less for single than for multiple reproductions, in the proportion of 2 : 3. (3) The increase of the Average Error follows Weber's Law approximately. (4) Practice decreases the Average Error. (5) Fatigue shortens the judgments; the effect of practice is to lengthen them. (6) The feeling of inner tension (*Anstrengung*) or attention is proportionally indicative of the accuracy of the judgment. (7) Pathological individuals show diminished sensibility and great irregularity of judgment, especially for long intervals, the Constant Error reaching wider extremes in both directions. (8) Distraction of attention by the metronome and arithmetical problems caused decrease of sensibility for long intervals and shortening of judgments, the latter especially for short intervals.

Comment: The objections repeatedly raised against results chiefly obtained upon a single experimenter, apply here again. The manner in which the results are combined and mathematically analyzed with reference to the influences of practice and fatigue offers great opportunity for merely fortuitous results, when based on such limited investigations; it may be doubted as of the similar calculations for the Law of Periodicity whether the same methods would again show like results with other experimenters. Otherwise the work is careful, thoughtful, and valuable.

HUGO MÜNSTERBERG. *Beiträge zur Experimentellen Psychologie.* Heft, 2, Freiburg, 1889.

This paper presents theoretical explanations, rather than experimental results. It aims to found all time phenomena on physiological processes; unless experimental results are correlated with their physiological causes, Münsterberg estimates such as "mere heaps of pedantic figures," and he is inclined to look upon all previous time experiments from this point of view. Münsterberg traces attention to feelings of muscular tension, and finds in our various rhythmic bodily processes, the indispensable measures and foundations of all time judgments. For short intervals, he thinks the rhythmic tensions of the sense organs themselves, are the basis of their

respective judgments, but the processes of respiration preponderatingly determine our time measurements, though unconsciously. A gradual rise and fall of tension-feeling accompanies each corresponding rise and fall of the equal inhalation and exhalation phases; according as impressions fall into like or unlike phases of respiration tension, or endure through like or unlike periods or multiples of such, so are they associated with, that is, measured by these familiar and judgment-determining processes.

The paper is one of the most thoughtful and suggestive yet contributed to the time problem, and a step in the right direction whether we give full acceptance to the particular theories announced or to his experimental results. His manner of presenting the latter is unfortunate; he tells us that "in cold blood" he suppresses the full figures until he "can prove what each period in the process means;" yet he gives his main results, if we understand him, as confirmation of his explanations regarding these same "periods."

Experiments: Wundt's time-sense apparatus as used by Glass, was arranged so that by an electric circuit, and a delicate key held in the hand, the subject could record his judgments while assuming any comfortable position, whether sitting or lying. Both the norm and reproduction were beat by the same electric hammer, enabling both the judgment of the norm and of the reproduction to be formed under the same conditions. The judgments were not, however, always fixedly recorded, but the position of the index each time the hammer fell was noted by two assistants, and averaged; with single reproductions, the assistant stopped the wheel when he heard the hammer fall; Münsterberg thinks the reaction-times involved do not exceed .05 to .08, and are too small to need correction. The experiments were of two classes — with and without a pause between norm and reproduction. The subject was never informed as to the character of the judgments he was making. The intervals tested ranged from 1 to 60 seconds. The method of average error was used. The only experiments for which definite results are given were 400 trials made upon Münsterberg himself with intervals from 6 to 60 seconds. The chief feature of these was, that two parallel series of tests were made; in the first, no regard was paid to phases of breathing; the second set was arranged so that the reproduction should begin in the like phase of breathing to that in which the norm had begun. This was accomplished, when the reproduction followed the norm without pause, by the assistant ending the norm (and thus beginning the judgment) upon the same phase of the subject's breathing as it had begun in; it will be noted that this always confined

the length of the norm to the length of the breathing or multiples thereof. Where a pause was made between norm and judgment, the assistant gave the signal for the judgment to begin, in the same phase as that in which the norm had begun, thus making the pause of variable length.

Results: No details are given. It is stated for experiments made without pause that when no regard was paid to breathing, the average error was 10% of the normal, and but 2.9% when the judgment and norm began in the like phase. For experiments with pause, the error was 13.3% when breathing was neglected, and 5.3% when like phases were maintained. When voluntary violent interruptions and variations were made by the subject during the tests, "judgment was entirely upset, 4 seconds appearing like 12, and 9 like 3." Münsterberg looks upon these results as evidence that there is no special function of *consciousness* to be called the time-sense, but that psycho-physically conditioned changes, which constitute the rise and fall of our bodily or muscular tensions, and chiefly those of breathing are the measures of our time presentations. "It is not the physically unconditioned transcendental apperception which functionates in time perception, but our time perceptions are the results of those physiological excitations which underlie our periodic changes." No constant error appeared in Münsterberg's work ; the judgments were for all lengths about as frequently positive as negative.

Comment: If Münsterberg had asserted that one *may* measure off certain intervals of time by his breathings, no one would object; but that our functional rhythms unconsciously govern our time judgments, there is grave reason to doubt; if several such functions simultaneously formed our time measures, what confusion would result; yet what reason is there according to Münsterberg that one function should influence, and another not? Why the breathing and not the heart? The latter expending more energy, why should its rhythms not predominate over those of breathing? Why may not the peristaltic movements of the intestines disturb the influences of both heart and lungs, if such unconscious functions may influence judgments at all? Again, were breathing the chief measure, we should expect that the ordinary person could more accurately indicate the length of the usual breathing interval than any other, whereas this is not at all the case. I incline to believe that the interval most fixedly

impressed upon the conscious memory is the one that may be most exactly reproduced. The workman who has closely tended a particular trip-hammer for a course of years, would be more able to judge the time-beat of that hammer than the length of his breathing. Most of us are more definitely familiar with the tick of our clock than with our respiration rhythms which constantly vary; I could not tell if my ordinary breathing was faster or slower than usual; while having had unusual practice in second beats of a pendulum, I could instantly tell to a very small fraction, if a beat, newly heard, were longer or shorter than a second. I should judge correctly, it seems to me not by my breathing, but because the reproductive process of the higher centres constituting memory had acquired a fixed periodic habit of its own. Sufficient explanation of Münsterberg's experimental results may be found in the fact that his methods confined his tests to intervals of about one given length, or to the multiples of that length, namely, that of breathing. If the same number of experiments had been equally confined to any other interval, it may be suspected that a similar phenomenon, due to the practice or habit being thus limited while forming, would have been observed. Yet beside this, inasmuch as the published figures were only those tested upon Münsterberg himself, we must again re-iterate the great liability to the unconscious influence of prepossessing theories and conceptions.

F. SCHUMANN. *Ueber Contrast-Erscheinungen in Folge von Einstellung.* Preliminary communication to Philos. Seminary, University of Göttingen, Dec. 3, 1889. Nachrichten v. d. könig. Gesell. d. Wiss. No. 20.

In certain memory experiments similar to those of Ebbinghaus, letters were pasted at regular intervals upon a revolving drum and observed through a slit; Schumann noticed, that when the eye or the attention had for a considerable time become adjusted to, or familiar with a definite rate, *a*, of presentation of the letters, any immediate change to some other rate, *b*, caused the latter to be differently estimated than if the previous adjustment upon *a* had not occurred; if *a* were shorter or longer than *b*, the judgment of the latter in consequence appeared respectively shortened or lengthened. When the physical and mental condition was good the attention was better, and rapid intervals seemed shorter than

when reverse conditions obtained. Similar results were observed when metronome beats were presented under like conditions to the ear; when the attention had been adjusted to an interval of .7, one of .9 was judged longer than previously to such adjustment. Dr. Schumann thinks the sensory centres are the seat of these phenomena; that they adjust themselves to a given rhythm, and thus prepare themselves, as it were, to expect excitation at a given time. If the rate of excitation is changed, the expectation is unfulfilled, and the subject is surprised into a judgment longer or shorter by contrast. Experiments of a like nature were also made in measuring given distances; by drawing the finger along a scale by motion of the arm, similar results were obtained.

Comment: The explanation offered by Dr. Schumann for the phenomena discovered by him seems, at least, inadequate; to say that the sensory centre, after adjustment "expects" a certain rate of excitation is vague in the extreme; but as this point is to be spoken of presently in detail the subject will be deferred.[1]

GEORG DIETZE. *Untersuchungen über den Umfang des Bewusstseins bei regelmässig aufeinander folgenden Schalleindrucken.* Wundt's Philos. Studien, II, 362. cf. also, Wundt's Phys. Psych. 3te Auf., II, 248.

Another line of experiments begun by Georg Dietze in Wundt's laboratory with reference to the so called Compass of Consciousness, was brought by Dr. Schumann into correlation with his above theories in a later paper.[2] The experiments of Dietze were to determine the greatest number of metronome beats, that, given in a series, and then repeated, could be determined to be the same in the repeated series as in the original; it was found that the larger series tended to group themselves into rhythmic multiples; it was claimed that these rhythms could never be entirely suppressed; the largest number of beats was found to be 40, and these were obtained by five groups of eight beats each.

Wundt contended that these 40 beats were in consciousness

[1] Owing to the resemblance between the phenomena reported by the above author, and those forming the chief part of my own work, to be presented later in this paper, this is perhaps the place to state that Dr. Schumann's Preliminary Communication of Dec. 3, 1889, reached my notice Jan. 10, 1890, at which date my own experiments had been under way about three months, and the method already established according to which they were carried out to the end.

[2] F. Schumann. Ueber das Gedächtnis für Komplexe regelmässig aufeinander folgender, gleicher Schalleindrücke, Zeitschrift für Psychol. Band I, Heft I, S. 75.

simultaneously; that they expressed the limit compass of consciousness, and that the addition of another beat to the end of the series, drove out the first of the series; Wundt explained this phenomenon by his well-known theory of Apperception. Dr. Schumann contends against this view, and believes that the hearing centres are capable of adjusting themselves to the reproducing of certain series which they had received with sufficient frequency; that they can repeat these series with more or less accuracy according as the habit has been formed with more or less fixity, and also in proportion to the favorable or unfavorable length of the interval and of the series; thus the 40 beats of Dietze express the extent of the habit-capacity of the hearing or memory centres, rather than any simultaneous compass of Consciousness or Apperception.

G. Stanley Hall and Joseph Jastrow: *Studies in Rhythm.* Mind. Vol. XI, No. 41, p. 55.

A work which approaches closely to many of the most fundamental processes of the time problem is the eight-page contribution of these experimenters. Two disks were fixed to the drum-shaft of a Ludwig kymograph; and cogs were fitted in their periphery in such a manner that, the disks revolving, and a quill pressing on the cogs, adjustable at various distances apart, intervals of different lengths and arrangment could be given as desired.

Three sets of investigations were made: to determine (A) for given intervals, what is the largest number of beats that can be accurately counted? The two intervals for which tables are given were .0895 and .0523. Of this set the authors say: "Counting objects and impressions is a very complex process, and slow, and hard to teach or learn. (1) The impressions in a series must of course be distinguished from each other. The ear, which does this most acutely of all the senses, unless it be touch, can discriminate $_{1}\frac{1}{3}_{2}$ (Helmholtz) or even $_{5}\frac{1}{0}_{0}$ (Exner) of a sec. under exceptionally favorable conditions. These of course are extreme limits, but from 24 to 40 beats per sec. can be distinguished by the average ear without fusing into a tone. The actual number of beats is also a function; that is in order that their discontinuity may be clearly perceived, four or even three clicks or beats must be further apart than two need be. When two are easily distinguished, three or four separated by the same interval approach nearer to the above limit and are often confidently pronounced to be two or three respectively. . . . (2) Counting requires a series of innervations, if not of actual muscular contractions. . . . The most rapid contraction

of antagonistic muscles in trilling by pianists who have given us their record, or the rapid lingual movements involved in aspirating the sounds *t*, *k*, recorded by a Marey tambour, we have never found to exceed and rarely to reach six double or twelve single contractions per sec., while few can make more than 4 or 5 double movements in that time. There is thus at any rate a wide interval between the most rapid innervations and the limit of discriminative audibility for successive sounds. Attention, in other words, discriminates sensation, more rapidly than the will can generate impulses How the fact is reconciled with any extreme form of the hypothesis of the identity of apperceptive and volitional processes is not easy to see. None would venture to assume that, because we can volitionally cut short the otherwise normal duration of a single innervation-impulse, by innervating an antagonistic muscle, the extreme limit of distinguishing elements in a series of noises marks really the limit of this abbreviation. (3) Counting involves the matching, pairing or approximative synchronization of the terms in two series of events in consciousness. However familiar both series may be, this is difficult. Many school-children find it hard to keep step with others or to keep time with a drum or piano in marching; and savages have been reported to sight across each stick, used as a counter for animals they were selling, to keep the correct tale. . . . What now becomes of the lost clicks when we are constantly behind in counting, yet with great subjective assurance that we are right? It will hardly be sufficient to say that, when counting with great energy and concentration, we cease to attend to the auditory series, stretching the interval we caught the *tempo* of at the beginning of the series, as all short intervals are expanded when we come to perceive only our innervations. We may, however, conceive the earliest announcement of the impression of the first click in consciousness and the exit therefrom of the registry-innervation involved in counting it, as separated in time by some not inconsiderable proportion of the simple reaction time between ear and tongue. If the interval between the clicks is greater than or equal to this reduced reaction-interval, consciousness is done with the first click when the second arrives, and there is no error. If, however, the second click begins to be recognized in the focus of consciousness before this has completely initiated the act of tallying the first, and if the fastest rate of doing so has already been attained, then the third click will come a little earlier in the process, until at length a click in the later afferent stage will cease to be distinguishable from the perhaps more widely irradiated process of the earlier efferent stage of tallying, and will drop out

of consciousness and be lost, possibly after the analogy of the second of two sub-maximal stimuli in myological work, which produces no summation if extremely near the first in time. . . . We do not realize how far the fastest counting falls short of the fastest hearing. In judging of small divisions of time, we seem, as Vierordt thought, to take relatively large periods, perhaps as great as our psychic constant (or the time we reproduce with least change)—so large at least that we can overlook it readily, and then pair or otherwise group the subdivisions which do not get into the field of direct time-sensibility themselves. The focus of apperception is perhaps dominated by the rhythm of the largest and more slowly loading and discharging motor cells. Although we can discriminate a finer intermittency by means of the smaller sensory cells, this is prone to be done more in the direct field of consciousness, and these smaller movements of time speedily fall out of sense-memory into oblivion like knowledge or impressions not directly reacted on. If immediately known time be discrete, and temporal continuity be an inference, as seems likely, these finer temporal signs are somewhat analogous to the finer local signs discriminating motion and even its direction considerably within the ordinary limits of discriminative sensibility for stationary compass points."

The (B) set of experiments investigated, "Just-observable Differences of Duration." Subjects D. and S. made each 20 judgments when the middle interval was varied $\frac{1}{60}$ of the 4.27 secs. of the extremes, viz., ten times each way with no error. G. S. H. judged 90 times under the same conditions with no error, while J. J. made only 12 errors in 90 judgments. When the variation of the mean was $\frac{1}{120}$ of the same time of the extremes, D. and S. made no errors in 10 judgments, J. J. made 3 errors in 40 judgments, and G. S. H. made 2 errors in 30 judgments."

The (C) experiments concerned "Full and Vacant Intervals." "It is well known that if a horizontal line be bisected in the middle and one half untouched and the other half crossed by short regular perpendicular lines, the latter half will seem the longer. It was found that under certain conditions the same illusion held for the time-sense. . . . Full tables were constructed for four individuals. With 10 clicks the following vacant interval to be judged equal to it must be extended to the time of 14 to 18 clicks; 15 clicks seemed equal to the time of from 16 to 19. Preliminary experiments upon other individuals indicate that these differences are extreme. If the absolute length of interval is increased beyond from 1 to 3 secs., the illusion is less. It is also less if the

clicks are very near together. The illusion still holds, but is diminished if, instead of comparing clicks and a vacant time, more or less frequent series of clicks are compared. In these observations, also, the time between the two intervals became quite important. In general the illusion was less if this time was short; but if less than about $\frac{3}{4}$ of a sec. the illusion again became greater. Indeed, in a few cases an indifference time was found in which little or no illusion took place. This entire illusion, however, is reduced to a minimum, and with some persons vanishes, if the order of the terms be reversed, viz., if the vacant or less-filled interval precedes."

A. BINET. *La concurrence des états psychologiques.* Revue Philosophique, Fév., 1890.

This paper deserves mention as an interesting study of the effects of attention upon time judgments.

Many investigations have been made upon such questions as, The Least Perceivable Duration throughout the various senses; The Least Perceivable Difference of Change for the same; Complicated results from several like or disparate sensations received simultaneously or in series. But as these are not sufficiently pertinent to our main problem the reader is referred to a good review of them in Wundt's Phys. Psychol. 3te Auf., II, pp. 330–364.

Casting an eye back over the experimental field of Time Psychology, the results are found scarcely more satisfactory or conclusive than were those of the preceding chapter on the theories of time perception. Most experimenters have confined themselves to the determination of the Constant Error, Sensibility and Weber's Law, yet with difficulty, if indeed at all, can the results of any two of such determinations be harmonized, as the following table shows:

Investigator.	Year.	Constant Error.			Periodicity falls on Multiples of.	No. of Reproductions.	No. of Persons Tested.	Average No. of trials per interval per man tested.	Method used.	Weber's Law.	Sensibility.
		+	0	−							
Höring, . . .	1864	.306–.365	.365–.454	.454–1.428	. . . . .	8	1	10	R.&W.C.	. . . .	Inverse to length of interval.
Mach, ...	1865	. . . .	. . . .	. . . .	. . . . .	. . . .	6	. .	L. P. D.	Does not hold.	Max. at .375 sec. thence both ways.
Vierordt, . .	1868	.25 (3.–3.5)	3. –3.5 2.2–2.5 Eye 1.4 (for H) 1.5 (for N)	(3.–3.5)–8.	. . . . .	{ 8 1 }	3	. .	Chiefly R.&W.C.	" " "	" 1.–1.5 " "
Kollert, . . .	1882	.4–.755	.755	.755–1.836	. . . . .	1	7	3	L. P. D.	" " "	" .755 " "
Estel, ...	1884	. . . .	. . . .	1.5–8.	(all) .75	1	10	2	L. P. D.	" " "	Follows inversely Periodicity .75 (all)
Mehner, . . .	1884	5.–12.1	{ .71 and 5. }	.71–5.	(odd ones) .71	1	1	10	L. P. D.	Does not hold below .71; Holds Appx. above 7.1.	" " " .71(odd) (Up to 7.1 above this is constant)
Glass, 1st set,	1887	.7	.7	.7–15.	(all) 1.25	1	1	100	A. E.	Held Appx. throughout.	" " " 1.25 (all)
" 2nd set,		.7–1.8	1.8–5.4	5.4–15.	do.	1	1	100	do.	. . . .	" " " " "
" 3rd set,		.75–2.	2. –4.	4.–9.	do.	1	1	100	do.	. . . .	" " " " "
Stevens, . . .		.71–2.85	.71	.26–.71	. . . . .	Through 1 min.	7	20	do.	do.	. . . . .
Ejner,	1889	30.–240.	Least at 120.	. . . .	. . . . .	25	Nearly all on 1	100	do.	. . . .	Greatest at 120. Decreases thence both ways.
"		. . . .	do.	30.–240.	. . . . .	1	6	100	do.	. . . .	. . . . .
Münsterberg,	1889	No Constant Error was found.			. . . . .	1	3	. .	do.	. . . .	Greatest in Equal Phases of Breath'g.

As a summary of these experiments the most conclusive results may be said to be as follows:

Nearly all persons, under nearly all conditions, find a particular length of interval more easily and accurately to be judged than any other.

This Indifference Point or interval of best judgment is very variable for different individuals and for different times and conditions.

The sign of the Constant Error is usually constant in both directions from the Indifference Point.

Where norm and reproduction are single the Constant Error is minus for intervals longer, and plus for intervals shorter than the Indifference Interval.

Where norm and reproductions are multiple, the Constant Error is plus for intervals longer, and minus for those shorter than the Indifference Interval.

The majority of evidence is strongly against the validity of Weber's Law; also against any fixed or constant Periodicity.

Later investigators look to physiological processes for explanation of time-judgments, and particularly to rhythmic habits of nerve centres. Whether such processes as breathing, pulse, leg-swing, etc., govern our perceptions, or whether the more general rhythmic functions of the higher cephalic centres are in themselves the basis of time-judgment is now the important question. The discussion of this question, together with the author's experimental results, will occupy the following sections of this study.

III.—EXPERIMENTS AT CLARK UNIVERSITY.

In October, 1889, I was requested by the instructor in Psychology at Clark University to investigate the apparently contradictory results obtained by various experimenters regarding the Constant Error of Time-judgments. As a preliminary, the methods of previous experimenters were tested, until after several weeks, a single, and perhaps crucial point seemed to stand out as the proper question upon which to concentrate investigation, namely, the effect upon our estimation of any particular interval of previous sustained exercise or practice upon some other interval. A long series of experiments was then regularly undertaken which lasted several hours daily, for a period of over nine months of actual experimental work. 27 persons were tested; over 500 "sittings," or series of reproductions were made, comprising a total of approximately 50000 single judgments recorded. Five lengths of interval were chiefly used, namely: .25, .50, .75, 1.25, 1.75, seconds.[1]

Apparatus: After trying different metronomes in various ways, these were abandoned as inaccurate. Previous to beginning our regular experiments a nearly perfect instrument for beating time was found in a pendulum constructed as follows: A stiff bar, thin but wide, and five feet long, swung upon knife edges projecting from opposite sides a little above the middle of the length of the bar, and resting upon smooth metal plates, was supported by firm frame-work. Upon each end of the bar was a heavy 'bob' or weight which could be slid up or down and fastened with a spring and clamp-screw at any distance from the point of support. With the first pendulum made, any length of interval could

[1] As before, the unit throughout this section is one second, except where specifically stated to the contrary.

be obtained, by proper adjustment, from half a second to two seconds, beyond which, beats could be regularly omitted from the electric circuit to be described, thus securing intervals of any length desired. The lower end of the pendulum-rod bore a platinum needle that at each swing made electric connection, at the centre of the pendulum arc, with a mercury meniscus. This pendulum, once set in full swing by the hand, would, for medium-length intervals, preserve regular beats for a far longer time than any single set of experiments, without any discoverable variation whatever. Great care was taken at each change of the interval to adjust the 'bobs' and mercury contact so as both to make the interval of exactly the stated length, and the back and forth swings precisely equal, these being the two matters needing the nicest adjustment in all pendulum motion. The pendulum was introduced into the same electric circuit with an ordinary telegraph key, a telegraph sounder, and a Deprez signal which wrote on the drum of a Ludwig kymograph with automatic spiral thread for the revolving drum. Another Deprez signal wrote the vibrations of a tuning fork upon the same drum, by means of a separate circuit and a König contact. For adjusting the intervals and beats for the first time, a fork of 100 double vibrations was used; the adjustment was extended through one hour, until a beat was secured, the sum of whose error was indistinguishable for that space of time, and therefore the error for any set of experiments practically zero. Two other pendulums were also made for shorter intervals, one of them giving quarter seconds. Any two of these pendulums could be introduced into different loops of the same circuit, and each being adjusted to a different interval, either of the intervals could by means of a bridge, be sent through the same sounder at the will of the operator and without stopping either pendulum; or again at will both pendulums could be cut out of the circuit altogether. The reproductions or judgments of the person undergoing experimentation were expressed by a slight movement of the finger upon an electric key that, by another Deprez signal in a separate circuit, recorded the judgment upon the kymograph drum. Thus during each set of experiments three electric signals with points arranged

over one another, precisely in the same line at right-angles to the motion of the drum, continuously wrote their separate records as follows: Number one recorded the vibrations of a tuning-fork; number two, the beats of whichever length of interval the subject was hearing from the pendulum sounder; and number three, the judgments of this interval expressed by the subject. The tracings on the drum were "fixed" and preserved.

As above stated the length of the reproduction was measured by tuning-fork vibrations written upon the drum; for all the experiments except those of table E, a fork was used making 50 double vibrations per second, thus recording hundredths of a second; for table E, which concerns intervals longer than the others (1.75), a fork of 25 double vibrations, recording fiftieths of a second was used. Many methods were tried for saving the enormous labor of counting these vibrations, which task, together with its strain upon the eyes for such a long series of experiments as the present, can only be appreciated by one who has tried it for several months. The slightly irregular motions of the kymograph make it entirely inaccurate merely to scale the intervals. The quickest and safest method of counting we discovered was as follows: When the paper is cut from the drum it presents on the sheet several parallel lines. Several scales were made fitting all the degrees of irregularity which the fork vibrations in these lines from time to time displayed; one of these scales was then selected to fit each line, part of a line, or set of lines according to their variation; usually three, and often one scale would fit the fork-record of a whole sheet; the eye quickly detects, after some experience, whether the scale fits or not, and thus enables the counting of the vibrations by using the scale as a tally, with comparative facility and absolute accuracy.

It is an important feature that in all experiments to be reported, great pains was taken to keep the persons experimented upon, in entire ignorance of the character of their judgments, or of any of the 'points' or the nature of the experiments whatever, in order to secure absolute freedom from unconscious prepossessions or subjective influences; where

this was not accomplished, as was necessarily the case in two instances, (subjects S. and L.), there was from the character of the men a minimum probability of subjective prepossessions. Moreover as by far the greater majority of the subjects were thus precluded from prepossession until their tests were completed, and as the records of the few who were not so precluded, including those upon myself, entirely accord with those who were, we think the results are reasonably free from this too usually neglected source of vitiation.

Method: The first class of experiments was conducted as follows: The subject was always seated alone in a noiseless room; the electric sounder and the recording key, both on a table before him, were the only apparatus within his sight or hearing; the former brought him through one circuit the beats of the metronome in sharp metallic strokes of uniform strength; with the latter he recorded his judgments upon the kymograph drum in another room. In the latter room with the kymograph was also the pendulum and remaining apparatus, presided over by an assistant. The precise method of these A experiments was invariably as follows: (1) The pendulum was started with full swing, giving beats .75 in length, the electric circuit remaining open. (2) "Ready" signals passed between assistant and subject. (3) Kymograph and tuning-fork were started. (4) The assistant closed the pendulum circuit long enough to send to the subject six beats, or five intervals of .75 each. (5) The assistant opened the pendulum circuit, silencing the sounder. (6) The subject meantime had sought to catch the beat of the sounder from the first beat of the norm and simultaneously to reproduce the beat upon his recording key during the 6 beats of the norm. After the sounder ceased, he continued to reproduce the interval, without breaking the continuity of the series, according to his closest judgment, these reproductions being recorded continuously by the proper circuit upon the drum. (7) The assistant permitted the subject to continue his reproductions until the drum had exhausted the full length of its spiral, when he signalled "stop." The drum was set to exhaust its spiral in two minutes; thus through all classes of experiments to be reported, the reproductions were extended through approx-

imately the same space of time, though of course the number of reproductions varied according to the length of the intervals used and the judgments made. Frequently short portions of the spiral would be used in adjustments of the signals or by accidents, so that the time actually used was shortened more or less. (8) After a few moments of rest a new beat, .9 long, or 20% longer than the norm was sent in to the subject, which with closest possible attention and care he strove to reproduce simultaneously, stroke exactly with stroke, during three minutes. No record was made on the drum of this exercise or practice. (9) A fresh drum having been put in the kymograph by the assistant during the above exercise, immediately upon the expiration of the three minutes, a signal was given to the subject to cease practicing. (10) A new series of 6 beats of the original norm of .75 was then given, and the above numbers (1) to (7) inclusive were repeated precisely as in their first order. In other words a new drum-full of reproductions of the .75 was obtained under precisely the same conditions as the first, with the exception that the first series was "Without practice" or exercise upon any particular interval, while the second set was under the immediate influence of 3 min. practice upon an interval 20 per cent. longer, *i. e.* on .9 (11) After a proper rest, still a third series or drum-full was taken precisely as before, except this time after like practice upon an interval 20 per cent. shorter than the norm, that is on .6

Thus was obtained at each "sitting," though with proper rest between each series, three sets of judgments, as follows: (*a*) without practice; (*b*) after 3 min. exercise upon .9 intervals; (*c*) after 3 min. exercise upon .6 intervals. Table A is arranged to show the comparative results of these three sets.

TABLE A.[1]

Norm, .75 sec. Practice, 3 min. each on .9 sec. and .6 sec. (20 per cent. longer and shorter). Trials, 17. Persons, 6.

(0), (+) and (—) indicate average reproductions made after hearing 6 beats, separated by a normal interval of .75 sec. (0) indicates averages made without practice; (+) after 3 min. practice on 9 sec.; (—) after 3 min. practice on .6. Where the (+) figure is greater than the corresponding (0) figure or the (—) less then the corresponding (0),

[1] The exigencies of space in the JOURNAL require the withholding of still more detailed tables carefully prepared and in the author's possession.

the figures are printed heavy, to show that these figures follow the rule that practice on a longer interval lengthens the judgment and practice on a shorter interval shortens the judgment as expressed in a following effort to reproduce the standard interval. The letters heading the vertical columns are the initials of persons acting as subjects. The small figures under each initial give the number of experiments from which the averages are made.

Set.	S. 5	L. 3	C. 3	F. 3	A. 2	N. 1	General Averages 17
(0)	.712	.607	.750	.735	.671	.814	.712
(+)	.710	.663	.727	.757	.749	.801	.723
(—)	.715	.614	.697	.706	.680	.731	.689

Results: With normal interval of .75, the general average of 17 tests upon 6 persons shows that there is a very slight and uncertain tendency to follow the rule that three minutes previous close attention to, and simultaneous reproduction of, intervals respectively 20% longer or shorter than the norm, correspondingly lengthen or shorten the judgment; that is, that the habit formed by the practice holds over to influence the succeeding judgments but slightly, if at all.

Series A being deemed inconclusive, it was followed by Series B, the only changes made being first, that a norm of 1.25 was used in place of .75, and second, that only two sets of reproductions were taken, namely: one without practice (0) and one after three minutes practice (—) on an interval of .25.

TABLE B.

Norm, 1.25 sec. Practice, 3 min. on .25 sec. Trials, 60. Persons, 12. At the head of each vertical double column is the initial of the subject. In the left hand column are the numbers of the single experiments from which the averages in the other columns are computed. The columns headed (0) contain average judgments of the 1.25 norm made without practice; those headed (—) similar judgments made after three minutes practice on a .25 beat. This table shows the average for each set of each individual, and also the general averages of each individual and of the total experiments of this table. The averages for this table are computed from the full number of reproductions of each drumful.

No. of Trial.	N.		S.		C.		L.		F.		A.	
	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)
1	1.423	1.328	1.332	1.275	1.244	1.146	1.245	1.166	1.597	1.517	1.138	1.212
2	1.453	1.303	1.470	1.403	1.229	1.169	1.238	1.091	1.437	1.425	1.379	1.319
3	1.530	1.317	1.748	1.343	1.278	1.276	1.222	1.258	1.491	1.446	1.368	1 349
4	1.321	1.252	1.313	1.306	1.316	1.307						
5	1.376	1 248	1.493	1.176	1.281	1.253						
6	1.333	1.287	1.519	1.328	1.335	1.280						
7	1.278	1.252	1.625	1.550	1.323	1.267						
8	1.249	1.189	1.515	1.522	1.334	1.307						
9	1.234	1.216	1.282	1.156	1.437	1.312						
10	1.346	1.277	1.226	1.209								
11	1.285	1.229										
12	1.336	1.185										
13	1.245	1.209										
14	1.350	1.196										
15	1.396	1.164										
16	1.337	1.265										
17	1·278	1 198										
18	1.296	1.186										
19	1.362	1.257										
20	1.381	1.287										
Gen'l Average.	1.335	1.242	1.435	1.313	1.306	1 253	1.236	1.167	1.506	1.461	1.291	1.290
Difference.	—.092		—.121		—.053		—.068		—.044		—.001	

TABLE B.—Continued.

No. of Trial.	W.		M.		Sh.		K.		Ca.		D.	
	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)
1	1.137	1.201	1.169	1.189	1.352	1.275	1.311	1 280	1.138	1.118	1.441	1.288
2	1.355	1.284	1.239	1.206	1.147	1 216	1.256	1.245	1.146	.954		
3	1.246	1.199										
Gen'l Average.	1.246	1.226	1.203	1.192	1.242	1.241	1.284	1.261	1.142	1.022	1.441	1.288
Difference.	—.020		—.011		—.001		—.023		—.120		—.534	

Results: Total General Average Without Practice, 1.3228″
" " " After " 1.2533″

Difference, .0695″

These B experiments upon the 1.25 interval, show an

almost universal shortening of those judgments which were preceded by three minutes close attention to, and simultaneous reproduction of, beats .25 long, the average difference between the judgments of the two conditions being .0695. The average difference of no individual out of the 12 included in the table varied from the general rule, and only in 6 trials out of the 60 was the rule broken for single trials, and no person broke the rule more than once. In general, those most experienced in laboratory work conformed most strictly to the usual law; the law was most frequently broken upon the first test made upon an individual, this happening 4 times out of the 6; and it may be remarked in relation herewith, that more variations should be looked for from nervousness or other disturbing causes under these conditions, and from those persons with whom they were actually found. In general, also, the amounts of the difference made between (0) and (—) was proportional to the amount of experience the subject had in psychophysical experiment; for instance, those for Dr. Donaldson, Dr. Sanford, Dr. Lombard and myself are among the largest. Curves were drawn for each individual similar to those of the accompanying chart. Study of these discovers that the Constant Error, whether plus or minus, shows itself most frequently to a marked degree, from the very beginning of the reproductions, and nearly always so before the seventh to the ninth beat, or in other words, before the elapse of ten seconds. Also, the Constant Error tends to preserve a uniform course from the beginning, either the judgments growing gradually longer or gradually shorter throughout the drum, according as their value is greater or less than the normal; in those individuals where the Constant Error is greatest and most marked, this gradual increase or decrease is most marked, as with Dr. Donaldson, where is the largest plus value, and with Dr. Lombard, where is next to the greatest minus value of the judgments.

A beat .25 in length was now chosen for the norm, and being shorter and more difficult to catch was always given 10 times as a sample for each set of reproductions, in place of 6 beats, as in the previous experiments. The practice interval was also changed for this table to 1.25, and for a period

of 5 minutes in place of 3 minutes, as formerly. The reason for this increase in the length of the time of practice is manifest when we consider that two factors enter into the functions of practice, namely: first, the number of repetitions which the subject or central cells would be called upon to make during the practice; and secondly the fatigue, nutritive, restorative, or other processes, which may depend somewhat upon the mere length of time which the practice is continued. We know little or nothing of the effects of either factor, but as in the C experiments practice on 1.25″ gave much fewer number of repetitions, the length of practice time was increased from 3 to 5 minutes, which was an indefinite compromise between proportional length of time of practice, and proportional number of beats.

The shortness of the interval would have given a great number of reproductions, since the same length of the drum's spiral was used as before; and the labor of counting so many would have been excessive; therefore, although the subject made his reproductions for approximately the same length of time as in the previous experiments, records were taken upon the kymograph of only the first 40 reproductions, and of a second set of 40, taken after the lapse of one minute from the last beat of the norm. All the other conditions were the same as before, making the method for Table C as follows: (1) Norm of .25 (10 beats given); a drumful of reproductions taken without practice. (2) Practice 5 minutes on 1.25 beats. (3) Norm of .25, (10 beats given); a drumful of reproductions taken after practice.

TABLE C.

Norm, .25 sec. Practice, 5 min. on 1.25 sec. Trials, 30, Persons, 8. Shows averages of each set and trial, of each individual, and the general averages as before. Averages of the first 40 reproductions are marked *a*, of the second 40, *b*; and the average of *a* and *b* is marked *c*; (0) without practice; (+) after 5 min. practice on 1.25.

No. of Trial.		S.		N.		H.		Ma.	
		(0)	(+)	(0)	(+)	(0)	(+)	(0)	(+)
1	*a*	.259	.289	.238	.241	.273	.289	.249	.261
	b	.245	.288	.230	.243	.232	.297	.242	.249
	c	.252	.288	.234	.242	.252	.293	.245	.255
2	*a*	.254	.255	.247	.248	.244	.262	.246	.249
	b	.239	.250	.243	.247	.225	.262	.238	.242
	c	.246	.253	.245	.247	.235	.262	.242	.245
3	*a*	.249	.251	.256	.248	.242	.259		
	b	.244	.244	.245	.242	.227	.251		
	c	.246	.247	.251	.245	.234	.255		
4	*a*	.261	.260	.237	.239				
	b	.243	.255	.234	.240				
	c	.252	.257	.235	.240				
5	*a*	.263	.265	.242	.252				
	b	.258	.255	.234	.248				
	c	.260	.260	.238	.250				
6	*a*	.259	.263	.246	.254				
	b	.254	.253	.238	.250				
	c	.256	.258	.242	.252				
7	*a*	.249	.265	.254	.261				
	b	.236	.262	.254	.259				
	c	.242	.264	.254	.260				
8	*a*	.253	.247	.242	.248				
	b	.256	.248	.217	.234				
	c	.255	.244	.230	.241				
9	*a*	.249	.246	.237	.246				
	b	.234	.245	.208	.237				
	c	.242	.246	.222	.241				
10	*a*	.245	.251	.243	.254				
	b	.234	.254	.231	.251				
	c	.239	.252	.227	.252				
Totals.	*a*	.254	.259	.244	.249	.253	.270	.248	.255
	b	.254	.255	.233	.245	.228	.270	.240	.246
	c	.249	.257	.239	.247	2.40	.270	.244	.250
Differences.	*a*		.005		.004		.017		.006
	b		.011		.011		.042		.006
	c		+.008		+.008		+.029		+.006

TABLE C.—Continued.

No. of Trials.	Ca.		B.		McD.		T.	
	(0)	(+)	(0)	(+)	(0)	(+)	(0)	+
1 *a*	.244	.252	.255	.253	.248	.249	.258	.252
1 *b*	.233	.253	.246	.250	.251	.252	.256	.245
1 *c*	.238	.253	.250	.252	.250	.250	.257	.249
2 *a*	.246	.251						
2 *b*	.250	.254						
2 *c*	.248	.252						
Totals. *a*	.245	.251	.255	.253	.248	.249	.258	.252
Totals. *b*	.241	.253	.246	.250	.251	.252	.256	.245
Totals. *c*	.243	.252	.250	.252	.250	.250	.257	.249
Differences. *a*		.006		.001		.000		.006
Differences. *b*		.012		.004		.000		.011
Differences. *c*		+.009		+.002		+.000		—.008

Results: Total General Average Without Practice (*a*) .2500; (*b*) .2396; (*c*) .2448.

Total General Average After Practice (*a*) .2557; (*b*) .2525; (*c*) .2542.

Difference (*a*) .0057; (*b*) .0129; (*c*) .0093.

These C Experiments seem to show that 5 minutes' practice upon a 1.25 beat, lengthens judgments of .25 intervals on an average .00935; the result is the more striking and conclusive when the smallness of the average lengthening is compared with its constancy, the "after practice" set of General Averages of the total 30 trials, exceeding the "without practice" set in every instance, and even in averages of three trials, as those of H (a subject who at the time was entirely ignorant of the purpose of his experiments), the "after practice" judgments falling below the corresponding "withouts" but twice out of the 240 recorded judgments. The Curves of the General Averages of the total thirty trials is shown in Fig. III of the Chart, and those of H in Fig. IV. The continuous line in the chart shows the judgments "without practice," and the dotted line "after practice" as previously in Figs. I and II.

TABLE D.

Norm, .75 sec. Practice, 7 min. on 1.75 sec. and 5 min. on .25. Trials, 30. Persons, 8.

This table will be understood without other explanation than that its method was precisely that of Table A, except that the 'long' practice was changed from 3 min. upon .9 to 7 min. upon 1.75, and the 'short' practice from 3 min. upon .6 to 5 min. upon .25; also, 7 beats of the norm were given for the copy from which the reproduction of each set was made. The table shows averages of each set and trial, of each individual, and the General Averages as before. Averages of the first 40 reproductions are marked *a*, of the second 40 *b*, and the average of *a* plus *b* is marked *c*; (0) = without practice; (+) after 7 min. practice on 1.75; (—)= after 5 min. practice on .25.

No. of Sittings.		S. (0)	S. (+)	S. (−)	N. (0)	N. (+)	N. (−)	H. (0)	H. (+)	H. (−)	B. (0)	B. (+)	B. (−)
1	*a*	.725	.786	.710	.801	.803	.747	.798	.764	.666	.705	.685	.648
	b	.726	.788	.690	.800	.814	.759	.835	.869	.670	.629	.621	.599
	c	.725	.787	.700	.800	.808	.753	.817	.817	.668	.667	.653	.623
2	*a*	.748	.835	.772	.781	.771	.751	.800	.878	.744			
	b	.766	.882	.792	.773	.798	.761	.899	.963	.794			
	c	.757	.859	.782	.777	.785	.756	.849	.920	.769			
3	*a*	.793	.795	.699	.739	.846	.712	.810	.982	.774			
	b	.801	.803	.718	.753	.844	.722	.894	1.148	.900			
	c	.797	.799	.709	.746	.845	.717	.852	1.065	.837			
4	*a*	.718	.795	.721	.736	.836	.696	.732	.909	.732			
	b	.699	.809	.754	.731	.975	.676	.794	1.056	.779			
	c	.708	.802	.737	.734	.906	.686	.763	.985	.755			
5	*a*	.768	.924	.727	.822	.826	.740	.787	1.003	.736			
	b	.746	1.019	.729	.790	.889	.716	.833	1.233	.794			
	c	.757	.971	.728	.806	.857	.728	.810	1.118	.765			
6	*a*	.782	.877	.735	.777	.804	.709						
	b	.761	1.120	.705	.775	.810	.704						
	c	.772	.999	.720	.776	.807	.707						
7	*a*	.781	.889	.778	.771	.820	.708						
	b	.824	1.118	.819	.770	.990	.693						
	c	.803	1.003	.798	.770	.905	.701						
8	*a*	.714	.816	.716	.761	.972	.722						
	b	.704	.822	.696	.798	.997	.727						
	c	.709	.819	.706	.780	.984	.725						
9	*a*	.758	.879	.744	.753	.961	.741						
	b	.768	.852	.743	.758	.952	.735						
	c	.764	.865	.743	.756	.956	.738						
10	*a*	.754	.840	.726	.747	.819	.788						
	b	.780	.855	.716	.751	.867	.777						
	c	.767	.847	.721	.749	.843	.782						
Totals.	*a*	.754	.843	.732	.768	.845	.731	.785	.907	.730	.705	.685	.648
	b	.757	.907	.736	.769	.893	.727	.851	1.053	.787	.629	.621	.599
	c	.755	.875	.734	.767	.869	.729	.818	.980	.758	.667	.653	.623
Differences.	*a*		+.089	−.021		+.076	−.037		+.121	−.055		−.020	−.057
	b		+.149	−.019		+.123	−.042		+.202	−.064		−.008	−.030
	c		+.119	−.021		+.100	−.040		+.162	−.059		−.014	−.044

TABLE D.—Continued.

No. of Sittings.		McA. (0)	McA. (+)	McA. (−)	Ma. (0)	Ma. (+)	Ma. (−)	Sh. (0)	Sh. (+)	Sh. (−)	Ca. (0)	Ca. (+)	Ca. (−)
1	*a*	.743	.739	.699	.695	.734	.641	.759	.835	.713	.702	.734	.679
	b	.708	.731	.635	.624	.708	.688	.731	.892	.720	.644	.687	.553
	c	.725	.735	.667	.659	.721	.665	.740	.863	.716	.673	.711	.616
Totals.	*a*	.743	.739	.699	.695	.734	.641	.759	.835	.713	.702	.734	.679
	b	.708	.731	.635	.624	.708	.688	.731	.892	.720	.644	.687	.553
	c	.725	.735	.667	.659	.721	.665	.740	.863	.716	.673	.711	.616
Differences.	*a*		−.004	−.044		+.039	−.054		+.076	−.122		+.032	−.023
	b		+.023	−.073		+.084	+.064		+.161	−.011		+.043	−.091
	c		.010	.058		+.062	+.006		+.123	.024		+.038	.057

General Average of All.	Totals. *a*	.758	.838	.722
	Totals. *b*	.762	.897	.725
	Totals. *c*	.760	.867	.724
	Differences. *a*		+.080	−.035
	Differences. *b*		+.134	−.036
	Differences. *c*		+.107	−.036

Results: Total General Averages Without Practice (*a*) .7583; (*b*) .7621; (*c*) .7602.

Total General Averages after practice on longer beat (*a*) .8385; (*b*) .8971; (*c*) .8678.

Total General Averages after practice on shorter beat (*a*) .7225; (*b*) .7255; (*c*) .7240.

Total General Average Difference after practice on longer beat (*a*) .0802; (*b*) .1349; (*c*) .1075.

Total General Average Difference after practice on shorter beat (*a*) .0358; (*b*) .0366; (*c*) .0362.

Comparison of experiments *A* and *D* shows that, for the same interval of .75, while in the former with a difference of 20 per cent. between the norm and practice intervals the effect of habit or practice was so slight as to be uncertain if active at all, in the latter experiments, with a much greater difference between the norm and practice intervals, the effect

was strong and constant. Figure V of the chart shows the curve of the General Averages for the 30 trials and 8 persons; figure VI shows the curve for Sh., and illustrates a single trial.

TABLE E.

Norm, .5 sec. Practice, 5 min. on 1.75 sec. Trials, 6. Persons, 2. The only other variation than those in the above line was for these experiments, that 10 beats of the norm were given for the sample from which each set of reproductions was made. Averages of the first 40 reproductions are marked *a*, of the second 40, *b*; the averages of *a* plus *b* are marked *c*; (0) = Without Practice; (+) = after 5 min. practice on 1.75.

No. of Trials.		S. (0)	S. (+)	N. (0)	N. (+)
1	*a*	.517	.541	.491	.521
	b	.503	.518	.484	.515
	c	.510	.530	.487	.519
2	*a*	.491	.528	.503	.523
	b	.505	.559	.483	.516
	c	.498	.544	.493	.520
3	*a*	.497	.535	.489	.498
	b	.504	.551	.484	.477
	c	.500	.543	.487	.487
Totals.	*a*	.501	.534	.494	.514
	b	.503	.542	.466	.502
	c	.502	.538	.480	.508
Differences.		+.033		+.020	
		+.039		+.035	
		+.036		+.028	

Results: Total General Averages Without Practice (*a*) .4980; (*b*) .4852; (*c*) .4916.

Total General Averages after practice on longer beat (*a*) .5246; (*b*) .5228; (*c*) .5237.

Total General Average difference (*a*) .0266; (*b*) .0376; (*c*) .0321.

Figure VII of the chart shows the curve for the general averages of the six tests of these experiments on the interval .5.

TABLE F.

Norm, 1.75. Practice 6 min. on .5. Trials, 6. Persons, 2. Seven beats of norm given for sample to be reproduced. (0) = Without Practice; (—) = after 6 min. practice on, .5 sec.

No. of Trials.	S.		N.	
	(0)	(—)	(0)	(—)
1	2.03	2.14	2.19	1.83
2	2.06	2.36	2.24	1.79
3	2.31	2.35	1.88	1.75
Totals.	2·136	2.284	2.049	1.790
Difference.	+.048		—.259	

Results: Total General Average Without Practice, 2.089
" " " After " 2.010

" " " Difference, — .079

It will be observed that the three trials of S. for this interval are all contrary to the usual law; whether this is accidental and due to the small number of the trials, or if practice is less efficient in its influence upon judgments of long intervals, is undetermined; we incline to believe the former.

At this point in the experiments it appeared conclusive that a certain amount of sustained exercise, with close attention to the repetition of definite beats heard from a pendulum or sounder, and reproduced by motion of the finger upon a key, induces some sort of more or less permanent effect or habit, whose influence unconsciously modifies accordingly the judgments or reproductions of other beats heard and reproduced immediately after such exercise or practice. The question now arose whether this effect was muscular or "central." To determine this, the following experiments were instituted; their method was the same as the foregoing except that in place of hearing the beats of the sounder the

armature or stroke-bar of the latter was pressed lightly between the thumb and forefinger of the *left* hand; the soft parts of the balls of the fingers were intruded slightly between the bar and the anvil or brasses between which the bar played, and, the circuit being closed, each time the pendulum made a stroke a "pulse-like" sensation was felt by the fingers. The left hand, thus holding the sounder, was then rolled in several thicknesses of cloth and folded with a woolen coat, and the ears closed with cotton or wax till no noise from the sounder could be heard with the closest possible attention. Also, the practice was now exercised or received in a purely afferent manner, without repeating the practice interval upon the key, simultaneously with the beats of the sounder as was done in the other experiments. By these means the effect of the practice was confined afferently to the left thumb and forefinger, and to their respective nervous centres. The reproductions of the trial intervals, both the set previous to practice and the correlative set after practice, were made with the right hand or fingers, as in all previous experiments.

It is evident that if similar effects from practice should manifest themselves under these conditions as in the former experiments, the cause could in no way be attributed to a muscular habit, because no muscles were at all concerned in the reproductions of the normal or trial intervals, which had been in any way influenced by the previous afferent exercise on the practice interval. Of course it is possible that every afferent impulse occasions some efferent discharge, although the same be actively ineffectual; yet even if this did happen, we think it would be fair to assume that the cause of the difference between the two sets of judgments was central and not muscular.

TABLE G.

Norm, 1.25. Practice, 6 min. on .25. Trials, 50. Persons, 16.
Practice taken by touch alone in left thumb and finger, the beat being inaudible. Ten beats of norm given as sample for all reproductions. (A) = Averages without practice; (B) = Averages after 6 min. practice on .25 beats; D = difference between (A) and (B).

TABLE G.

No. of Sittings.		S.	N.	L.	H.	C.	A.	D.	B.
1	*A*	1.276	1.200	1.065	1.480	1.339	1.146	1.433	1.442
	B	1.215	1.109	.942	1.530	1.390	1.111	1.437	1.334
	D	— .061	— .091	— .123	+ .050	+ .051	— .035	+ .004	— .108
2	*A*	1.302	1.174	1.025	1.443	1.564	1.396		
	B	1.202	1.033	1.238	1.410	1.475	1.393		
	D	— .100	— .141	.203	.033	— .089	— .003		
3	*A*	1.247	1.140	1.358	1.447	1.289	1.446		
	B	1.195	1.029	1.159	1.282	1.438	1.480		
	D	— .052	— .111	— .199	— .165	+ .149	+ .034		
4	*A*	1.207	1.082	.883	1.388	1.307	1.493		
	B	1.350	1.058	.882	1.223	1.255	1.420		
	D	+ .043	— .024	— .001	— .165	— .052	— .073		
5	*A*	1.390	1.245	1.093	1.333	1.277	1.553		
	B	1.281	1.071	1.012	1.233	1.284	1.369		
	D	— .109	— .174	— .081	— .100	+ .007	— .184		
6	*A*	1.174	1.179						
	B	1.109	1.085						
	D	— .065	.094						
7	*A*	1.350	1.326						
	B	1.353	1.202						
	D	+ .003	— .124						
8	*A*	1.322	1.261						
	B	1.289	1.089						
	D	— .033	— .172						
9	*A*	1.583	1.271						
	B	1.335	1.154						
	D	— .248	— .117						
10	*A*	1.334	1.213						
	B	1.361	1.031						
	D	+ .027	— .182						
Totals.	*A*	1.310	1.210	1.061	1.416	1.347	1.389	1.433	1.442
	B	1.262	1.083	1.029	1.326	1.363	1.312	1.437	1.334
	D	— .048	— .126	— .032	— .090	+ .016	.077	+ .004	— .108

TABLE G.—Continued.

No. of Sittings.		McM.	W.	Ha.	M.	Mi.	Ma.	Hn.	Ca.	Average of last 10.
2	*A*	1.301	1.350	1.408	1.372	1.425	1.029	1.183	1.268	1.306
	B	1.163	1.210	1.397	1.474	1.322	.906	1.194	1.161	1.245
	D	— .138	— .140	— .011	+ .102	— .103	— .123	+ .011	— .107	— .061
Totals.	*A*	1.301	1.350	1.408	1.372	1.425	1.029	1.183	1.268	1.306
	B	1.163	1.210	1.397	1.474	1.322	.906	1.194	1.161	1.245
	D	.138	— .140	— .011	+ .102	— .103	— .123	.011	— .107	— .061

General Average, { 1.277 / 1.213 / — .064

Results: Total general average without practice, 1.2776

Total general average after 6 min. practice on, .25, received only through left thumb and finger, 1.2137

Total general average difference, —.0639

The results of these *G* experiments are particularly to be compared with those of Table *B*, both having had the same norm and same practice intervals. The length of time which practice was undergone, however, was in *G* double that in *B*, which probably should be counted as a reason why the difference between the "without practice" and the "with practice" results should have been greater in *G* than in *B*. An offset to this influence, however, lies probably in the fact that in the *B* practice the intervals were not only afferently received, but also efferently executed, bringing into play the whole psychophysical arc of sensory centers, motor centers, and muscles of the fore-arm, hand and fingers; under these circumstances this arc soon takes on, as a whole, a simultaneous function of a strongly reflex nature, the reproductions not following the beats of the norm, but precisely and spontaneously coinciding with them, beat on beat; the whole process of reproducing here is itself of the nature of an induced habit, and it is natural to suspect that the continuation of the habit, sustained through the term of practice, would have a stronger and more lasting

effect than where the sensory centers alone were exercised, as in the *G* experiments. What the precise results of these countervailing conditions may have been we cannot determine, but the very close equivalence of the total differences of the two tables (— .0695 for *B*, — .0639 for *G*), is very likely to have been within certain limits accidental.

It is not likely that the same experiments repeated under conditions as nearly as possible like these, and upon the same individuals, would produce precisely the same results, for the human organism, mental and physical, is so complex, its environment so variable, the entire conditions of the problem so multifariously changeable, that the mathematical probabilities are almost infinitely against identical combinations. But results constantly like in nature and approximately like in degree, should, we think, be deemed scientifically acceptable. Even with these, the time-problem is so difficult and so liable to subjective and delusive complications, that we cannot look upon the experiments here reported, (as extensive, careful and conclusive as we have endeavored to make them,) as being entirely conclusive until they shall have been confirmed by similar work of other experimenters. With these provisions, however, we think the results of the foregoing experiments indicate that, *sustained attention to a rythmically repeated impulse induces in the corresponding nervous centre a habit or tendency to continue that impulse, which habit influences, or modifies succeeding time-judgments.*

The following table summarizes our results with reference to the Constant Error. We have thought best to give the length of the judgments rather than the amount of the error; the plus sign is prefixed to those judgments which are greater, and the minus signs to those which are less than their corresponding norm; also, the table shows the number of trials from which each average is calculated, and the table from which the same are taken. The judgments of Table *H* are alone the first series of each set or trial, that is, those made without practice or normally.

TABLE H.—CONSTANT ERROR.

Persons.	Norm .25		Norm .50		Norm .75		Norm 1.25		Norm 1.75	
	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.
					5 A	— .712	10 B	+1.435		
S.	10 C	— .249	3 E	+ .502	10 D	+ .755	10 G	+1.310	3 F	+2.136
					Average	— .741	Average	+1.373		
					1 A	+ .814	20 B	+1.335		
N.	10 C	— .239	3 E	— .480	10 D	+ .769	10 G	—1.210	3 F	+2.049
					Average	+ .773	Average	+1.293		
							3 B	—1.236		
L.					3 A	— .607	5 G	—1.061		
							Average	—1.126		
							9 B	+1.306		
C.					3 A	+ .750	5 G	+1.347		
							Average	+1.321		
H.	3 C	— .240			5 D	+ .818	5 G	+1.416		
							3 B	+1.291		
A.					2 A	— .671	5 G	+1.389		
							Average	+1.353		
							2 B	—1.142		
Ca.	2 C	— .243			1 D	— .673	1 G	+1.268		
							Average	—1.184		
Ma.	2 C	— .244			1 D	— .659	1 G	—1.029		
Sh.					1 D	— .740	2 B	—1.242		
							2 B	—1.203		
Mi.							1 G	+1.425		
							Average	+1.277		
F.					A	— .735	3 B	+1.506		
W.							3 B	—1.246		
							1 B	+1.441		
D.							1 G	+1.433		
							Average	+1.437		
B.	1 C	+ .250					1 G	+1.442		
K.							2 B	+1.284		
McD.	1 C	+ .250								
T.	1 C	+ .257								
Bl.					1 D	— .667				
McM.							1 G	+1.301		
W.							1 G	+1.350		
Ha.							1 G	+1.408		
M.							1 G	+1.372		
McA.					1 D	— .725				
Hn.							1 G	—1.183		
					17 A	— .712	60 B	+1.322		
General Averages.	30 C	— .244	6 E	— .491	30 D	+ .760	50 G	+1.277	6 F	+2.089
					Average	— .742	Average	+1.302		

Results: With the method used, the experiments, on the whole, indicate that the judgments of intervals of .75, .50 and .25 are very slightly shortened, while those of 1.25 and 1.75 are considerably lengthened. Too few intervals were used to determine the Indifference Point accurately, yet in view of the great variations displayed, we may perhaps come as near the truth as can be well attained, if we calculate this point, for these experiments, from the General Average of the intervals used; according to such computation the Indifference Point would appear to be about .81. Yet so great are the individual differences and even the variations of the Constant Error from time to time for the same individual, that this error should be termed Inconstant rather than Constant, and as calculated from any number of persons yet experimented upon, must be considered as extremely problematical and uncertain. Particularly so, as we entirely lack any sure clue to its probable cause. In view of the indication arrived at, that the phenomenon is central, we might infer that the lengthening of the judgment was due to an inertia or tardiness of the centres to repeat the proper rhythm, and that this might be based upon a failure of response in nutritive processes; but this would be difficult to reconcile with the fact that the more rapid intervals, which would be supposed to exhaust the centres most quickly, display the opposite tendency and act more quickly than they ought. Or perhaps the relations between the nutritive and active functions of the centres, are an automatically compensating mechanism, wherein the supply is sometimes "over corrected" and again "under corrected" with reference to the exhaust, just as the balance wheel of a watch is often at fault with reference to temperature, and the watch varies with the season and with the pocket it is carried in; so the time-mechanism of the nervous centre may vary with individual and physical conditions, and with the coat we wear; surely the psychical timepiece is not less delicate or complex than its horological rival of human skill.

Comparing our own results with those of former experimenters, though we learn next to nothing of the cause of the Constant Error and too little of its course to predict

dict the same with any great probability, for any certain person or number of persons; yet study of our tables, and still better of the original curves and charts too numerous to publish, reveals a few points of considerable certainty. Those individuals who make the largest constant error, make the error most constantly in one direction; such persons, also, are apt to make a constantly increasing error throughout the series of reproductions of each drumful; this phenomenon betrays itself even more conspicuously in the "after practice" series than in the "without practice" series; the phenomenon is illustrated in the judgments of L and of H in Table *G*, and in their respective curves, Figures X and XI of the chart; judgments of the former are unusually short throughout the experiments, and in the curves, show themselves growing rapidly shorter and shorter to the end of the drum; the judgments of H are unusually long throughout all his trials, and his curves go rapidly up throughout each drum. This raises a serious question as to what the magnitude of the Constant Error would be for a longer and different period of reproduction. Possibly, also, this point has relation to the fact that contrary signs are found for the Constant Error by the German experimenters who used single reproductions, and by Mr. Stevens (with whom my results pretty closely agree) and myself, who used multiple reproductions. Examination of the first reproduction of each drumful of my work, does not discover the contrariness of sign for Constant Error, between the first and the subsequent judgments of the series, which would correspond to the contrariness of results between the above mentioned experiments with single and with multiple reproductions. New experiments seem needed for the tripartite relations between the sign of Constant Error, the number or length of time the norm is given as a sample, and the number of the reproduced judgments.

Another feature of interest is, that any slight nervousness or excitement of the subject shortens the judgments. Often the subject who sits for the first time, looks upon any psychological experiment as in some way a test of mental caliber; this, together with fresh interest in the experiment, occasions a slight eagerness, excitement, or mental tension for the first

trial, which is not so much, if at all, present in future ones. Examination of results taken under such conditions, convinced me while the experiments were in progress that they were shorter than the ordinary ones. It is evident that this, if true, would have bearing upon the method of our experiments; for instance, if in first sittings the average judgments of the first or "without practice" trial be for the above reason shortened more than the following "after practice" set, allowance ought to be made for this in estimating the shortening or lengthening effect of the practice upon the later set; otherwise, in those cases where the practice interval was shorter than the norm, the shortening effect of the practice in the "after practice" set would be negatived to the extent of the shortening due to excitement in the "without practice" set, and the reverse for practice intervals longer than the norm. Examination of the tables shows that the law, that the "after practice" sets are longer or shorter than the "without practice" sets, according as the practice interval is longer or shorter than the norm, is broken to a more or less degree in 48 out of 246 times; 17 out of these 48 digressions occurred in first sittings, and 11 out of these 17 occurred in those experiments where the practice interval was shorter than the norm. This is in accordance with what has been said regarding excitement, yet a more detailed scrutiny of the results than is possible to give here, is chiefly the ground for what we have stated on this point.

Much has been said by previous experimenters concerning the effects of attention. Undoubtedly with single reproductions sensibility and accuracy are directly proportional to the attention given; with multiple reproductions it is doubtful if this is the case for the expert and experienced subject. For myself, who have had very unusual experience, my best judgments are made by paying the greatest possible attention to the norm during the sample beats, and then, when the rhythm is once caught, abandoning myself to as near an unconscious or reflex condition as possible, letting the idea or habit of the rhythm run its own course undisturbed, as near as may be, by attention, volition, or any kind of thinking whatever.

Subjective opinions of one's own judgments: After finish-

ing each drumful the subject throughout the experiments was usually asked his opinion of how well he had kept his copy or norm; only in a small and uncertain number of cases were these opinions found to agree with the truth, and frequently were directly contrary.

How long before the effect of practice shows itself as against the immediate memory of the norm? The results are so variable that this question cannot be answered with precision; nearly always the effect of the practice is exhibited in the very first reproduction to a marked degree; before the expiration of 8 or 10 seconds the effect would seem to be in full force or tendency, from which time forth, the judgments where the Constant Error was well marked, gradually grew longer or shorter to the end of the drum, as we have before stated.

How long does the effect of practice last? Our method did not permit us to observe a longer period than from 1.5 to 2 minutes; the practice seemed to preserve its effect with nearly, if not entirely, its full force for that length of time.

Fatigue: A few experiments were made preserving closest possible attention to the beats and judgments for several hours at a sitting; sample tests of the judgments were taken from time to time. So far as these go, fatigue could not be discovered to have any effect whatever.

Long Experience in making time judgments has been thought by Mehner and others to lessen the Constant Error. Study of the above experiments according to their dates on the protocol, which also agree with the order of the tables as published, discovers very uncertain evidence for this opinion, a slight probability perhaps inclining in its favor.

Mr. Stevens noticed in his work, that judgments of unusual length or shortness are apt to be corrected in the following judgment, "according to a standard which the mind carries, but to which the hand (or perhaps the will during the interval) cannot be accurately true." To a certain degree the same phenomenon is observed in my charts and curves, though I am rather inclined to carry back the cause to some automatically compensating adjustment of the rhythmic habit or

function of the nerve centres, than to the vague phrase "a standard carried by the mind."

Anomalies: Seeing no just reason for the culling out of anomalies in former experiments, I have permitted none in my own. Every test taken in the course of any regular experiment has been reported in its proper place, with the exception of a single trial each, for three persons, who, from nervousness (one was a young woman) or lack of rythmic sense, were entirely unable to catch the beat of the norm in a way that would enable them to repeat it with any sort of regularity or likeness to the original.

Sensibility: Owing to the enormous labor that would be involved in computing the Average Error for so many judgments, no investigation was made by me of this factor. On the whole, however, I should say the nearly uniform results regarding sensibility of all former experimenters, which constitute almost their sole point of agreement, are entirely confirmed by the experiments here reported.

In closing this account of my experiments I have pleasure in thanking those who have given me so much valuable time, taken from their own University work, in acting as subjects for such a tedious and time-robbing investigation, and those also who have assisted me by suggestion, counsel and inspiration.

IV.—CONCLUSIONS.

Sensations and their images or reproductions have various attributes; qualitatively they are blue, or warm, or painful etc.; intensively they are strong or weak, bright or faint, etc. Duration, or continuation, is another attribute or characteristic of every sensation and of every image. This attribute is the ultimate and essential datum of time. Besides sensations and images, science infers and assumes the real and separate existence of certain physical elements, having fixed correlations with each other, and with sensations and images. Whether the grounds for this assumption are acceptable or not we need not here discuss; but according to this assumption, duration or continuing is also an attribute or characteristic of these physical elements, and therein forms a further

field of this ultimate and essential time datum. Again most philosophies, and, I think, all religions and all science, assert, infer, or assume the existence of some soul or super-psychical cause, as an ultimate element separate from, or as a further attribute additional to, the physical elements and the sensations and images; according to these grounds there is thus another field of this characteristic time datum. Thus our time datum is seen to be an attribute belonging to, and inherent in, everything that is conceived to exist. As such, also it is seen to be an ultimate datum; as much so as the blueness, the chilliness, or the painfulness of any sensation, or the existence of anything at all. Why things exist at all, or why their inherent nature is what it is, we think to be at present beyond human explanation. The fundamental datum of our present explanations, then, we shall state to be that time *is* this attribute of duration wherever it exists.

This being the nature of time, what constitutes a perception of time? Hoping the results will justify the use, we shall accept that nomenclature according to which it is said that every elementary sensation or image is *perceived* which presents itself in consciousness at all. When a sensation or image properly occupies the focus of attention, we shall say it is *apperceived*. According to this terminology, time is perceived whenever any sensation or image durates[1] in consciousness at all; it is apperceived when the duration properly occupies the focus of attention. Thus if we suppose a creature so simple as to be without memory, and capable from time to time of but a single elementary sensation of constant quality, say a pain, (such perhaps are some infusoria) we should say that pain was *perceived* whenever it occurred; we should not say it was *apperceived*. We should also say such a creature *perceived* time.

Why sensations ultimately differ at all, why some are red and some blue, some bright and some faint, or why some are long in duration and some short, is beyond explanation. That some are long and some short is an ultimate datum, and no more wonderful than that sensations are diverse in any other

[1] I have coined this word, finding no other sufficiently simple in meaning.

way. But in the same way as we shall say of our simple creature that he perceives his sensation when it exists at all, and that he perceives time when it (the sensation) durates at all, so we shall say he perceives a certain definite time when it durates in that certain definite manner. Its perception is its occurrence; the ultimate nature of its occurrence, constitutes the ultimate nature of the perception; the definiteness of its occurrence, of its inherent nature, constitutes the definiteness of that certain perception. We know nothing of the perception of such a creature except by inference and analogy; but in the same way that we should say his sensation is painful, in that same way we should say one of his perceptions was five seconds long. And in the same way that we have said he perceives time when his sensation durates at all, so we shall say he perceives five seconds when it durates five seconds, and perceives one second when it durates one second. But according to this, one thing above all else must be carefully noted, *perception* or perception of time duration is *always a process and never a state; a certain definite time is a certain definite process.* We can no more discover an explanation of our perception of the duration of five seconds alone in some mysterious momentary mental arrangement or "temporal sign," or other *instantaneous* characteristic, than we can discover redness in blueness; for us to perceive blue, there must be blue; for us to perceive duration, something must durate; for us to perceive a definite blue, there must be a definite blue; for us to perceive five seconds, something must durate five seconds; for us really to *perceive* a year, some definite sensation would have to durate a year. What takes place when we say we have an *idea* of a year is another matter which we shall discuss in its place.

So also of series of sensations. That series occur at all is an ultimate fact or datum. What actually occurs when a series occurs we shall call a perception of a series. And in the same way as we can never perceive a half-second except something durate a half-second, so we can never perceive a series of five half seconds with intervals of half seconds between the terms, unless such a series occurs. When it occurs its entire occurrence will constitute its perception. Actually

to perceive such a series a year long, such a series would actually have to occur throughout a full year. What takes place when we have an idea of such a series we shall also discuss in its turn.

Neglecting for the present any consideration of the correlation between them, or of any perception of such a correlation, all that we have said regarding sensations applies as well to images or reproduced sensations; really to imagine five seconds, some image must last five seconds; fully to imagine a thousand clock-ticks, a thousand clock-tick images must pass through the mind. So also, fully to remember a thousand second-beats, a thousand second-beat images must pass in full mental review.

And as of pains, and clock-ticks, and second-beats, so of all other mental content whatsoever and however disparate. Mental process is mental perception; every definite or certain process or procession is a definite and certain perception; and every definite perception is also a definite time perception. Yet we must not forget that according to the nomenclature we are now using, perception is not apperception, and a definite time perception is by no means an apperception of a definite time; this we shall come to later.

What we have said of perception applies as well to memory. But when we *say* we remember an occurrence, we seldom, and indeed never, except the occurrence is short, simple and of recent happening, remember it as accurately and fully as it actually transpired. That is, in its re-presentation in memory, some of the items drop out of the process, or rather fail to drop into it; and the remainder stand *unsuspected* for the former whole — do so for the very reason that the former whole now is not, nor can be suspected at all, except in and through so much as *is* re-presented. I may have spent the whole of yesterday listening to the second beats of a clock, yet I may quickly remember that I did so, without the entire day and each tick repeating itself in full or in any instantaneous miniature of fullness in that quick remembrance. But in this quick remembrance, it is probable the entire mental procession of the previous day was re-presented alone by some momentary flash-picture, as it were, of myself as I was seated

at some particularly striking moment of yesterday, listening to the clock; perhaps this flash-picture or remembrance lasted long enough to take in no more than two represented ticks of the clock; perhaps to take in but one; or it may be that *all* the image-ticks were left out entirely and only the word "tick" or "clock" occupied their place in the quick remembrance; for such, it seems quite certain, is the nature of much of our thinking. If that in the above quick remembrance which occupies the place of, stands for, indicates, or symbolizes the original series be named the *idea* of that series, then the idea of that series is not a full representation of that series in any way. And it is plain also that we have in such an idea no such occurrence as that described by Herbart, or Mr. Ward, or any of those who conceive that an idea of a series, or of succession, or of time, must be some sort of instantaneously painted picture presenting the whole length of the time or of the series in a simultaneous perspective. Indeed if needed at all, there would seem to be needed as much such an instantaneous sidewise view of the duration of the simplest sensation and of the briefest part of time in order to perceive that it durate at all, as to perceive that it durates for, say, five seconds. The classic question therefore whether the idea of succession is or is not a succession of ideas, in so far as the question is one as to whether the idea is a longitudinally passing *process*, or a sidewise presented *state*, may as well be fought out with reference to the nature of any original sensation and for the briefest temporal portion of it, as with reference to any train or series of such sensations. Whether a sensation, an image, or a series of such, it does not matter; the pertinent question is, do we perceive the length of any duration, however long, by the *process* of that duration itself, or by some non-processional representative state? The chief arguments or suggestions I have been able to formulate or to find formulated for the "state" theory, all root, it seems to me, in the delusive catch-phrase, "We can not *now* perceive something that is *really past*, therefore our perception of past must be a *present* perception, *i. e.* a state." But this phrase is a series of verbal mis-statements and bad logic from beginning to end; we do not "*now*" perceive this some-

thing, whatever it is, but so far as I can discover we "now-now-now-now" perceive it; we do not stand still and look along the line to measure this past in a perspective view, but *run* along the line as it were (a new line representing the old) to measure it inch by inch, or present by present, by a moving process over again; nor is this something that we re-measure a "really past," nor in the absolute sense do we *re*-measure at all; but the "really past" and the original measuring both gone forever, a new representation of the gone past and a new measuring of the new representation happen "brand-new;" happen in original *representation* of them, though not in re-*presentation* of them. All this being so, our phrase carried out in good logic should read "We *can not* 'now' perceive something that is really past, therefore our 'perception of past' must *not* be a present perception, *i. e. must* be a *process*. On the other hand, the evidence for the opposite or "pro cess" explanation seems to me consistent and even positive. I think that every one who will observe his own mental process when he seeks to measure or to realize the length of any durating sensation or its representation in memory, will easily observe that he never fully perceives or remembers the length instantly or even approximately so; unless, of course, the duration is itself instantaneous or approximately so. On the other hand I think any one will easily convince himself that *fully* to perceive or to remember the length of its representations, these representations must stretch themselves out through an equal process and lapse of time as did their original occurrence. 'Quick ideas' of the nature described above may delusively flash upon us with approximate instantaneousness, but never a full and complete idea, and the time occupied by the idea will be proportional to its completeness.

Another evidence in favor of the process and against the "state" explanation lies, we think, in the following facts. The items of a long series, say the detailed events of a past hour, never are fully represented to us. It is easy to account for this according to the process theory; many of these details fail to reappear, and as the serial reappearance of those which do reappear is our sole suspicion of their presence, or of their order of appearance past or present, so of those which

fail to appear, we *at the time* have no suspicion of their absence or of the fact that they ever existed. At some other time we may remember further details, and also remember this abbreviated memory, and so become aware that we have dropped items from the latter. But according to the "state" theory, it is difficult to conceive why those causes which give the proper perspective to any part of a series where no items are gone, should not give the proper *perspective* to those items which do appear in a series when some items do not appear, and why such a perspective state would not have much such an aspect as the perspective of a picket-fence where some of the pickets are on and some off. Nor must we imagine such a conscious running-over of yesterday's incidents, as one in which we skip or jump from one incident to the other and almost feel the shocks occasioned by gaping items, to be just such a broken-fence perspective as we above describe. Surely such a series of shocks are a process and not a simultaneous state, even if we are conscious of the gaps; but how we come to *be* conscious of the gaps in this running perspective, is a complex question entirely separate from the one under present consideration, and one we shall hope to throw light upon later. That we do not have simultaneous picket-fence perspective with pickets visibly off, that is with perspective gaps belonging to lost items, is quite evident in our attempts to recall the precise number of ticks in a given series just heard; where as those who have had much experience must observe, they frequently with confidence think they recall the whole series perfectly and with no consciousness of gaps, though there are gaps.

We are inclined to conclude therefore that by the same process that we perceive the duration of any smallest part of any single sensation, by precisely the same nature of process we perceive the duration of any sensation however long and of any series however long; that the duration of the sensation or series, the perception of the duration, and the perception of the length of the duration are one and identical; that the duration is an ultimate datum, and no more capable or needful of other explanation or of further analysis than the blueness of a blue spot.

But perception of the length of a sensation, the apperception of its length, and the perception and apperception of its length as measured by some other sensation, are different matters altogether, as also are so-called perceptions of past, present, and future, and of other definite time relations, and of dates; all of which we must now consider.

More often than otherwise those definite sensations which come through the focus of the eye are those which determine the immediately following ideas; with great frequency these sensations definitely persist long enough to associate for some time with the ideas which they call up. With less frequency the definite sensations of hearing, touch, smell, and so on down the scale, determine the immediately following associations. Frequently very obscure sensations such as a red spot at the very edge of the field of vision, or the temperature of our teeth direct the association. Or perhaps as often as otherwise the particular mental group which determines the association is not a sensation or procession of sensations, but a definite group of images or procession of images which we may call an idea. Whatever group it is that determines the succeeding association, that group we say occupies the focus of attention, the terminology being evidently derived from the fact that the focus of vision is so frequently also the focus of apperception. Apperception is complete association; the object of association is always the object of apperception, and the object of attention. The focus and the object are always identical. When we apperceive anything we couple it with its most usual associations, that is, memories of its own attributes, qualities, and characteristics. This kind of association *is* apperception. Time is apperceived when any process of duration occupies the focus of attention, is the object of association, and calls up durative associations; that is, memories whose characteristics are particularly of the duration quality or nature.

We must with GREATEST *care distinguish between perceiving time and apperceiving time relation.*

Perceptions of relation are commonly supposed to be involved in the very core of the indissoluble mystery of the unity of the mind. We are deeply aware of the importance

of the subject, yet we have been driven to suspect that the secret of perceived relations is to be found in that they are associative processes of the apperceptive degree or nature and not simultaneous states. This subject is not our main question and we shall discuss it but in so far as is necessary for our explanation of time relations. If two tones precisely alike in quality, intensity, and length, begin precisely together and end together, no relation will be perceived between them. If one begins perceptibly before the other, relations will appear. Without some qualitative or some intensive *change* there can be no temporal *relation*. The occurrence of the change in the qualitative or intensive nature of the perception *is* the perception of the relation; and in the same way as it is not some necessary sidewise simultaneous perspective that constitutes perception of homogeneous duration, but the ever flowing attribute of duration itself, therefore we suspect, that every perception of temporal relation is fundamentally the actual procession of one term of definite quality or intensity followed without gap by another term of different quality or intensity; that actually to perceive any definite time relation or change, such must actually transpire; andfully to imagine or to remember such, the corresponding representation of it must again pass through the mind in full review. Without qualitative or intensive change no series could occur; such change is the essential characteristic of a series; the change *makes* the series. Fully to perceive the relations of the terms of a series the full series must be experienced either in original occurrence or in representation. To perceive that A B C D occurs in the relations a b c d it must occur in these relations. To perceive that B is after A, A must happen, then B. To perceive that A is before D, A must happen before D. To apperceive these relations is something quite different. To perceive that D is present and that A B C are gone, A B C must come and go and D must come; the apperceiving of the presence of D, or of the goneness of A B C, or of the relation of the presence of D to the goneness of A are other matters that need much elucidation.

To apperceive D it must occur, stand in the focus of the mind and call up images representing its qualities and usual

associations; to apperceive it as *present*, it must call up the idea 'present'; the apperceived relation of D to the Present is the occurrence of D followed by some idea of "the Present." For us to understand this relation we must understand "the idea of the Present." The word "present" is one that we associate with the continued presence of any mental content, or more strictly speaking with the durative procession of that content through the mind; thus we can associate the word with a passing image as well as with a passing sensation; but most commonly the word Present associates itself with the bodily group of *sensations* which we call self and with the environmental sensations which happen to be present at the moment that we are so apperceiving 'the Present.' Thus when we apperceive D as *present* the process that nearly always occurs is something as follows: first D itself, then the word "present," then some durating procession, most probably some sensation procession of our body or our surroundings at the particular moment. The length of this last associated durative procession is variable; in quick apperceiving, as in quick remembering it may be little more than the word 'present' alone; or it may be the quick flash of some mental duration even without the word "present."

But while on this subject we must not let words confuse several distinct data. Strictly the *perceived Present* is the content of any perception at the time of its occurrence; is that occurrence itself. Similarly the *apperceived Present* is the occurring object of apperception; that which directs the association. But to apperceive *the* Present that is, to apperceive the mental content actually occurring *as* the Present, that is again to perceive its *relation* to the Present, this occurring content must call up, and be associated with, the idea "Present"; that is very likely with the word "present" followed by some durating procession very probable to be a continuation of the surrounding stream which was the object of apperception from the beginning; in other words the apperception of the Present *as* the Present is usually but a sustained association of the word "present" with the progressive flow of the sensations within us or from around us. The *change* which reveals the relation, that is, the change which

constitutes the relation, in so far as a relation is a psychological occurrence, is the change occasioned by the dawning appearance of the associated idea.

So much for the Present, for apperceiving the Present as the Present, and for apperceiving D as present; now for the 'goneness' of A, B or C — the Past. Strictly speaking, mental content has no Past and no Future; they are only while they are, and their existence is like a mathematically moving point, or speaking of the total content, is like a plane moving at right angles to itself. What then is this moving procession by which, as we say, we have knowledge of the Past?

From what we have discovered regarding Present, we may suspect that perception of Past, perception of past relation or relationship, apperception of Past, and apperception of past relationship are all different matters. As the existence of any temporal portion of any mental content constitutes a perception of Present, so the *cessation* of its existence, constitutes a perception of Past. In order to perceive Past, some sensation or image must *cease*; whenever any such ceases, we perceive Past; the ceasing of the perception is the perception of Past; did no perception ever cease we should never perceive or know anything whatever regarding Past, or pastness, or about *the* Past.

To have a perception of past relation, a *relation*, that is, as we have explained, a *change*, must occur. To perceive a temporal *relation* between A and B, B must be different from A, and to perceive the relationship the relationship must occur; and we shall perceive whatever occurs, and we shall perceive it as it occurs, while it occurs, and in its occurrence; and we shall *only* perceive what occurs and while it occurs, and in its occurrence. To perceive A before B, A must occur and B succeed. To perceive B after A, A must occur and B succeed. The *perceptions* of the relation, A before B and B after A, are identical because the relationship A before B is the relationship B after A. The *apperceptions* described by these two phrases we shall discover may be quite different.

For an apperception of Past, the cessation of some sensation or image must call up some *idea* of Past, of something ceasing; striking or familiar examples, those which most for-

cibly impress memory, are those most *likely* to be called up; yet the least possible flitting perception of something ceasing would suffice for the associated idea; or even merely some word, such as "past," "gone," etc.

When we come to apperception of past relationships, we arrive upon confusing and difficult ground; not because the essential and typical process is different from all other apperception, but because the associated ideas are so varied in number and kind, and our uses of language so loose and delusive. First we must note that an apperception of Past is not an apperception of past relationship. For example, A may occupy the focus of attention and its cessation call up associations of ideas of pastness. In this case B did not occur at all, and in the associations brought up, the pictures are of single terms ceasing. This is apperception of Past. But to apperceive any temporal *relation* A B, the change A B must occupy the focus of attention and its occurrence call up by association some *idea of relation*; that is, some mental picture of change, some *a* followed by some *b*.

Our space will not allow us to analyse all the apperceptions of temporal relationships of past, nor is it necessary to do so; a few important types will give the key to all. Perhaps the most crucial in the whole time problem is that which takes place, when, as we say, we perceive that something is *of* the Past; a moment *ago* I knocked on my table so hard that it hurt; I heard the knock and then felt the pain. What in my mental process constitutes this "ago"? Clearly the "ago" is a relationship with some present. But what sort of relationship? a perceived or an apperceived one? And with *what* present? Is it with "now-now-now-now"? Or are we to speak of some particular "now," that "*now*" is not "now" at all, but as we shall see a mere idea of "now." When I felt the pain, I was not *thinking* about its time relations, that is I was not apperceiving such. I did *perceive* the time relation of the sound to the pain; I did not *apperceive* it. It is quite possible that a representation of that sound may pop into my head again immediately after actually hearing a similar sound; I shall then perceive a time relation between that representation and that sound, but I shall not necessarily *ap-*

perceive any time relation between them; *whether I do or not will depend on whether the occurrence determines the subsequent current of association; and the kind of relation that may be apperceived will depend upon the kind of associations that are called up.* Suppose I do hear a similar sound at some future time of my life, and by some favorable condition determined by my surroundings or thoughts at that time, a representation of the former sound and of all its surroundings at its time of occurrence be by association again brought into the focus of apperception; that having thus sprung into mind *by* association they should then dominate and determine by association the next and following course of apperception and so on. What takes place here is a present sound like a former sound, followed by a representation that is like it and also like a former sound, followed in turn by a panoramic representation of that certain stretch of my past life that happened when I struck the table, heard the original sound, felt the pain and so on. Thus far there is in all this no apperceived "ago," no apperceived time relation, merely this panoramic representation of the Past is passing through my mind; I have not yet apperceived or, as we say in ordinary language, I have not yet *recognized* that it *is* the Past; no least thought of the temporal *relation* of all this panorama nor of any part of it, not even of the represented knock, to the Present may have yet occurred to me. What shall we say so long as this panorama goes on and no direct time-relation to the Present is thought of? Shall we say all this is nothing but imagination? This question I think brings us to one of the most usual sources of confusion for our entire subject. Usually we *do* call just such panoramas as this memories, and remembrance, whether we do actually stamp their date upon them and think their "ago," or their "how long ago" or not. The vast majority of the representations of those things which have happened but a moment or a few moments before, we have no need to date and do not date. The stream of thought or apperception into which they rise is not one regarding time relations or time characteristics, or time recognition. For instance, had I been writing an explanation of pain instead of time, the same panorama of the table, my

hand moving toward it, the thump, the pain, would have occurred as now when I write of time; but from this point instead of a train of associations of time nature being set going, a train of pain relations would have been set going; that is I should have apperceived pain and not time. The mere passage of past panoramas through the mind in no way constitutes a *recognition* that they are of the Past, or of how long they are past. Presently I shall show the difference between imagination and this sort of undated, unrecognized memory; we are now examining dated memories, and we wish to know in what this dating consists over and above the mere passing picture. From what we have discovered, this should be comparatively well understood. First regarding the knock we may merely *think of it past*, without bringing in the Present or any particular time relation; that is we may merely *apperceive it past*: in this case its image or representation will merely bring up in apperceptive process, ideas of Past; the image of the thump will cease and ceasing images will follow; perhaps the representation of the knock will continue to occupy the centre of the stage for some time, will continually go through the process of ceasing and of setting associated images to ceasing; and for the time the whole play will be a regular variety performance of ceasing, while we may or may not be saying all the time or repeating all the while to ourselves the *words* 'past, past, past'; or 'thump past,' 'thump past'; or if we had been less engrossed with the particular performers, any portion of it might have sufficed; a single "tumble" or cessation of the first comedian Thump himself, followed by a tumble or two of the associated company; or if even less engrossed, a mere glimpse of Thump followed by the word "past" would have completed the theatrical bill. This is the simplest form of apperception of the relation Past; the *change* is that from the ceasing thump representation, to the associated ceasing representations; the *pastness* lies in the relational change to the associated idea of ceasing, and this idea is composed of the associated ceasing representations.

Next we may apperceive that the thump happened *before* the pain; here 'Thump then Pain,' 'Thump then Pain' will be the chief theatrical performance, in imitation of the origi-

nal actual occurrence; if we are not in a critical mood this pantomime may suffice even without the word "before"; the *repetition* of the main performance may constitute the idea; or if we are more reflective and exacting, the whole company may be called out, and the whole stage be set whirling with mimic and peek-a-boo representations of 'beforeness.'

The "show," for apperception of the fact that the pain happened *after* the thump, would differ little from the last above. Pain here would come on to the stage first, making the bow, as it were, that introduces the "show," instead of Thump, as previously, and he will probably make an extra bow between each alternating bout between him and Thump, just to make sure that we keep our eye mainly on him; and every time he makes such a bow he (or we) will say "after," or to speak more soberly, the word "after" will say itself by association, instead of the word "before" saying itself.

The play by which this Thump-Pain representation is apperceived, *i. e.* thought of in relation to the moving Present, may now be easily understood; we here no longer look alone at the stage, but we take in the whole view around us, from our body outward and, as well, from our body inward. Thump-Pain are the chief actors on *the inner stage* as before; they are the *first* objects of apperception from which the course of thoughts wanders momentarily down among the audience, that is to our actual 'now-now-now' surroundings, and inward to our own bodily sensations and even to attention to our own thoughts; but now and anon our focus of attention flits back from these actual Presents to the show 'Thump-Pain,' again viewed on the mimic stage of memory. And as we have said of simple apperception of Past, so of this process of apperception of 'having happened before the Present.' Here the play may be longer or shorter according as we are more or less reflective; a twinge of neuralgia may suffice for the moving Present, with or even without the word "present" or "now"; and a single bow from Thump or Pain, that is a single memory image of these may suffice for their remembrance, or there may follow a full apperception of 'Thump-Pain past,' that is of the *ceasing* of the thump and of the pain, as described above.

We have now described what takes place when, as we say, we think of a thing or event as past, and when, as we say, we think of something as *of* the Past; that is, past with reference to the moving present. But particular time-relations, such as yesterday, last week, a year ago, ten minutes since, remain to be discussed. But as this brings up the subject of *measured* time, let us postpone these for a word concerning so-called perceptions of Future. As the fundamental sign of every idea of Present is the *continuation*, and that of every idea of Past is the *cessation* of some representing image, so the fundamental sign or characteristic of every idea of the Future is the *beginning* of the representing associated images. When I think of the Future of things, I think of them as *beginning*. As I go over a familiar way, memories of the path ahead of me beyond my view keep *rising* in my mind and constitute the foundation of expectation. If I apperceive these expectations, as expectations, the associations are those of the *act* of expectation, plus the panoramas of the path. In this case, *I* enter into the "show," the whole moving action of my bodily feelings while I sit here or walk there and expect; that is, certain holdings of the head, wrinkling of the brows, laying my finger to my chin, or the like; meanwhile the stage show goes on, the performances now being emphatically those of the "beginning" nature or plot, together with little mimic side pantomimes of myself in the acts and experiences of expecting; also the orchestra plays "future" "future" the while, or anon, plays "expectation" "expectation," and the panorama of the path ahead of me moves on in ever beginning glimpses. Apperception of Future, and apperception of *the* future, are similar to the apperception of expectation, and, I think, need no further explanation than may be derived from the above.

But how do we *measure* time length, and measure "how *long* ago," and "how long until?" When speaking of our simple creature capable of but a single constant sensation, we said that when his pain lasted five seconds, he perceived the length of five seconds, and when it lasted one second, he perceived the length of one second. We distinctly declared he did not apperceive either length, and from what we have said

of change and relations it is clear that I have not conceived that this creature perceived relations of any kind; neither relation of difference nor of number. Here we must be most careful not to let our customary use of language and our common processes of thought designated by common language, confuse us as to the actual elementary processes of mind which we never experience singly, and for which consequently we have no common or definite designations; and, what is more usual, have no definite or apperceived conceptions. Until some one opened our understanding to the matter, we went on deludedly imagining that we saw distance through rod-and-cone processes, the same as we did blueness; now we discover that what we call *seeing* distance is chiefly not seeing at all. It is probably the same with all the ultimate elements of sensation; Prof. Wundt reminds us that we never experience them singly, and so with great difficulty arrive at any conception of what each or any one element singly of itself is like, or what its various attributes are like. We should be prepared therefore to comprehend, since apperception of length and of number is not perception of length or of number, and again since perception of *difference* of length, and difference of number, (these all involving changes and relations) are not mere plain perception of length and perception of number, we should, we repeat, yet be prepared to comprehend that perception of five-seconds length is not in ultimate nature the same as perception of one second length. That there is a difference here, we think it comparatively easy to demonstrate, though it is quite certain that we do not ordinarily apperceive the difference, that is, do not form and associate ideas of it with its occurrence. It is probable, in our ordinary apperceptions of time length, that the associated *ideas of length*, which make up the apperception, are those representations or memories of muscular tensions, dermal stretchings or joint pullings, which fundamentally are the components of our ideas of motion; consequently has perception of time been so commonly founded on perception of motion, from Aristotle down to present psychology. There is little doubt that the intensive changes, which are the characteristics of these motion sensations, are the striking and

characteristic components of those associated ideas which enter into our ordinary apperceptions of time length. But we must not fail to note that these changes are not the only components of these ideas, and that these image processions, and also their prototype original processions, are not *all* change; there must be duration without change in order for duration with change to be possible. And in the same way that we continually *perceive* changes different in degree of change, without *apperceiving* any difference, so it is probable, and I think certain, that we continually perceive durations of different lengths without apperceiving their difference. For example, of our simple creature I think one should now have no difficulty in conceiving how there might and would be a difference between his perception of a five-second pain and his subsequent perception of a one-second pain, and yet this creature never perceive the difference; that is, might not have any relational idea of such a change, as we might find to constitute the process of perceiving or apperceiving *difference*.

Prepared, therefore, not to confound actual difference with perception of difference, let us examine these matters more closely. We found that duration and change are ultimate data; we shall also discover that differences of duration are also ultimate facts. We shall never discover why ultimately these differences are differences, but given these differences, we shall discover, I think, how we come to perceive, and finally to apperceive, these differences, and in what these processes consist. Carefully considering the matter in the light of the experiments reported in Chapter III, I have been led to suspect that this perception and apperception of durative differences may rise in two ways, which, for convenience, I shall here designate as the single method, and as the multiple method. These experiments emphasized the fact long before determined, that our so-called memory images are dependent upon certain reproductive *habit* processes of our nervous and bodily organism. Were it not for these "habits" we should have no memory. My experiments emphasized *the degree to which the validity of correlation between these so-called memories and their originals, depends upon the validity of these organic habit processes.* If the habit is not accurate,

the memory will not be faithful, *although we shall not have the least suspicion that it is not faithful.* The truth is, the memory may be altogether different in temporal length from the original temporal length without our perceiving or recognizing their difference, or suspecting anything about such a difference whatever. Nothing can bring out more clearly than this, that *actual* difference does not constitute recognition of difference, and that perception and apperception and recognition of difference are all some sort of processes quite different from and additional to mere actual difference of occurrence. *To apperceive these differences, they must, by association, bring up certain qualitative ideas and ideas of difference.*

We do not yet know positively the particular portion of the brain organism, whose rhythmic reiterative habits are chiefly responsible for memory; it is sufficient, however, for our present purposes that it is *some* particular portion of nerve organization, which, for convenience, I shall here designate in accordance with present probabilities, as the central nerve cells. My experiments demonstrate that when these cells functionate with reiterative temporal accuracy, our time judgments are accurate, and as their habit varies or is disturbed, our judgments vary correspondingly. We have also to observe how frequency and lateness of original occurrence form and influence this iterative habit. We have then to note, that immediately after the occurrence of a definite sensation, which previously has been frequently repeated, say the tick of a metronome, two forces, or to speak more accurately, the tendencies of two processes, are contending against each other in the production of the succeeding memories; and, indeed, as well in the production of the succeeding *sensations* themselves. The cells, both those which functionate the memories and those which functionate the tick sensation, (be they the same or not, we do not know) tend on the one hand to follow the rhythm to which they have previously been trained, tuned or accustomed, and on the other hand, to adopt a new rhythm in correspondence to the rythmic impulse then and there received from the metronome. Not only, therefore, is the result likely to be ever a compromise between the two, and our sensations at different times and under various conditions, likely to vary

from the actual metronome rhythm and from each other, but quite possibly another result of more peculiar nature may also happen from and during this contention of tendencies. For instance, suppose the metronome to be beating quarter seconds and the cells to have been tuned or adjusted by preceding practice according to the method of our experiments to second beats. Plainly by the law of association and habit, the first stroke of the metronome sets going the tendency of the cells to perform their second-beat representations; and consequently the impulses sent in from the succeeding second, third and fourth beats of the metronome will find the cells in a different condition than did the first beat. Precisely what would be the nature of the result of this contention or disturbance of the regular order of things, or what the difference between this and the case where the old habits of the cells should be entirely overcome by the new influence, or where the cells from the beginning were accurately adjusted to the beat coming from the metronome, is difficult to say. It is well to note, however, that this condition of contention between new and old influences or habits is the usual condition rather than the exception; and that any peculiarity of sensation or feeling which should result, as is very likely to result from such a struggle, might be a very important factor in time measurement. Not that such a peculiarity or temporal sign would of itself alone constitute *apperception* of time length, but reproduced representations, or repetitions of these different temporal signs among the associations constituting the apperceptive after-train of ideas called up by *actual* time differences, may be definite and determining data in such apperceptions of different time lengths. And in consequence of these contentions also, and of apperceptions which they determine, it is quite possible that in the *original occurrence* of familiar sensations we may have indefinite cognizance of "too short" or "too long" *without definite memory or apperception of that in relation to which it is short or long;* it is quite possible that these definite memories sometimes are and sometimes are not then called up by these apperceived signs. In short, during the original occurrence of a series we may, as it were, apperceive a general abstract definiteness of length or of time difference or

relation, without its being followed by concrete definiteness; that is, we may apperceive that it is definite without apperceiving its full definiteness, for such subtle tricks are, by no means, psychically uncommon. Should that which we have tried to describe be true, those theories which have sought to explain time relations and time perceptions by "temporal signs" or a disparate sense would have herein some foundation of analogy.

But more frequently perhaps are the rudiments of time measurements to be discovered in a method different from the above. Should an image occur simultaneously with its corresponding sensation, the two beginning and ending precisely together, this equality of their length, would, in accordance with our foregoing nomenclature, constitute the perception of their equal length. Without fuller description, we may understand how by association this perception would rise to apperception, and thence to apperception of their temporal equality. Similarly, if the image and sensation were of unequal length, we may comprehend how this would rise to apperception of their inequality. Again, if equal temporal series of simultaneous sensations and memories, or yet again, unequal temporal series of such, occur, we may also prefigure how these get apperceived, and what will constitute the nature of such apperceptive processes. But before we speak finally of such processes, a word must be said as to apperception of number, in order fully to elucidate how we apperceive a sensation to denote *so many units*, or to be so many times longer than another.

For four sensations to be perceived, four sensations must occur; for these to be apperceived, the idea of four, *i. e.*, the word "four," or some four image reproductions, or both the word and the four reproductions must be added in proper apperceptive process thereto. So of any other number of sensations or images. This is the key to the simple apperception of number. A sensation, four seconds long, may occur succeeded by four different sensations, each one second long; by our first method of measuring time length, combined with the apperceptive process of number, we may understand how we arrive at an apperception of one sensation being four times the length of another. Or a sensation four seconds long may occur

simultaneously with four sensations, each one second long; and so by the second method of time measurement, combined with the apperceptive process of number, these would rise to apperception of the one as four times the length of the other. And so on with other multiple number-measurings.

Before leaving finally this subject of habit rhythm and time measurement, a word more regarding those theories which have found in our main unconscious bodily rhythms, such as breathing, pulse-beat, and leg-swing, standard rhythmic measures of our time judgments. We have pointed out as objections to these theories, that we have no reason to conceive why one such unconscious process should dominate as a standard more than any other; yet for all to contribute such unconscious disturbances would, indeed, so we must think, lead rather to indiscriminate confusion, than to standard discrimination; such views, moreover, run quite contrary to the selective advantages of unconscious reflex actions, which, by relieving consciousness of all such disturbing vital processes, have made our conscious processes distinct and intelligible. Also we have mentioned that, according to the theories of breathing standards and the like, it would seem that we ought to have a more lively and accurate conception of the definite length of such processes as breathing than of any other duration lengths or rhythms, while, as a notorious fact, we do not; but rather those rhythms which we most customarily hear are those which most vividly rise up with accuracy and as standards. This brings us to the point on which we wish to lay further emphasis; and for this we would note that the particular function, to which our conscious centres seem to be differentiated in contradistinction from the reflex unconscious centres upon which our vital processes depend, lies in just their power and tendency *to adapt* themselves to the multitudinously time varied outer impulses to which consciousness is to correspond, and whose purpose it is to represent; their very peculiarity consists in differentiation to outward susceptibility rather than like the unconscious reflex vital nerve centres to a particular inward rhythm approximately undisturbed by outer influences. Nor must the fact shown by our experiments, that unusual frequency of repetition by the *conscious* cells of im-

pulses received from without tends to perpetuate such particular time rhythms or habits to the temporary detriment of accurate judgments of other rhythms or time lengths received from without, be counted against this view, but rather for it; for if there were *no* tendency for these conscious cells accurately top reserve their habit of repeating the occurrences from the outside, which were their original prototypes, there would never be any accurate time memories or images of our sensations at all, in fact, no rational memory whatever. The whole cerebral and central nervous organism seems a happy adjustment of fixity of habit, not too fixed, and susceptibility, not too susceptible. There would seem reason from *à priori* grounds to suspect, therefore, that which from observation seems to be the case, that our standards of time-measurements are memories of certain most striking rhythmical, habit-inducing, and oft-occurring outer occurrences, such as the particular length of watch or clock ticks, which we are most accustomed to hear; the sounding-hours; the varying lights and shadows of morning, noon and night; the peculiar Sundayness of Sunday and Mondayness of Monday; the varying seasons; perhaps also as we have surmised vague temporal signs or admonitions of passing moments and as well of passing years.

After all the foregoing, it seems unnecessary particularly to explain apperception of such time relations as "yesterday," "to-morrow," "last week," "a week hence," "a year ago," or "ten minutes ago;" these terms are but particular words associated with particular time occurrences and number measurements, which rise into more or less extended and definite processes of apperception of such relations, according to our reflectiveness of mood or passing mental circumstances.

We have seen that much of our thinking is comprised of image-trains representing past occurrences to which we attach no date; which we do not think of or apperceive as of the Past at all; that is, which we do not actually *recognize* as of the Past or as ever having been seen before. We have to repeat that in our belief some of the chief confusions of psychology, and as well of philosophy, come from commonly mistaking this mere passage before us of trains that *are* correspondent

to former trains for those mental processes which do properly constitute psychological recognition. It is curious to note that those metaphysicians and psychologists, who most stickle against the possibility of any *real* recognition of any non-psychical *real* world, most unsuspiciously build their systems upon fancied *real* recognitions of past sensations in so-called present representations of such. The truth is that in the absolute sense we do not any more recognize sensations in their image representations than we recognize real things in their sensational representations. Until it dawned upon the human mind that its former so-called recognitions of an outer world could all be explained without the real existence of such a world, no one suspected the *reality* and *validity* of these recognitions; we now all admit such so-called recognitions to be but psychic processes; the *validity* of these processes and recognitions is, and we think must for a long time be, a subject of debate. We here wish only to point out that these parallel recognitions, so-called, of former sensations are likewise but psychic processes, the validity of which is as much open to suspicion, as inferred and as hypothetical as that of the so-called recognitions of a real world, and, indeed, vastly more so; for how commonly are our most confident memories mistaken, and our insane and hypnotic subjects engulfed in hallucination.

Still more is this truth forced upon us when we comprehend the details of these processes of so-called recognition; when we clearly understand the psychological difference between imagination and so-called recognition. If every one of us through life were but rational every alternate minute and insane turn and turn about every other minute, there would be no difference between imagination and reality. The grounds for our present belief in some real difference lies in the constancy of our belief itself, and when we come to examine into it, we find this belief is a hypothesis, an inference, and no *positive* knowledge. But what then are the grounds for this hypothesis? Plainly not in any simple direct cognitive act or state. We have sure reason to believe that our ordinary so-called perception of time relation is not a peculiar disparate state, but an apperceptive process; and similar analysis, I think, discloses to us that recognition is a similar apperceptive

tive process, and that imagination is still another such a process. The difference between imagination and recognition lies first in a marked difference in the character of the thoughts which form the objective process of the apperceptions, that is, to which the associated ideas are added in the two cases; and, secondly, in the character of these *added* or associated ideas or processes. And as it is the nature of apperceived associations to be of like character to the objects of apperception, we shall find that the difference between the associated ideas in our two cases corresponds in characteristics to the original difference between the objective processes themselves. What then is this fundamental difference between imagination and reality? We can only answer with an hypothesis, and this hypothesis is, that all things *do* occur in a fixed order, that all occurrence *is* a fixed order; that not all this occurrence is perceived by us; that certain of the total occurrences of the universe result in fixed and definite influences upon our brain organism; that like causes produce like results; that like stimulations produce like sensations; that like series of stimulations are followed by like series of sensations; that these physical stimulations *are* alike and these corresponding sensations *are* alike, though the mere occurrence of their likeness by no means constitutes our recognition of this likeness; that owing to the peculiar nature of our physical organism and particularly of our central nervous organism, whereby physical processes tend to repeat themselves, certain representations or repetitions of sensations corresponding to these processes in certain characteristics *do* tend to occur whenever these physical processes *do* repeat themselves; that the accuracy and scope of complexity of temporal correspondence between these representative processes and their originals depends entirely upon the habit validity of these physical reiterative processes; that our recognition of this validity and correspondence does not consist in some super-added cognitive act over and above those psychic processes which correspond to these reiterated physical processes, *but is entirely dependent upon, and to be explained by, a hypothetically actual correspondence or likeness of these reiterative processes, both phy-*

sical and psychical, to former processes, physical and psychical; finally, and again, that not even the mere validity of this correspondence alone comprises "recognition," but that recognition is a psychological process, the validity of which rests upon the validity of such correspondence. Our hypothesis is that the events of our lives do happen in a single definite actual order, which so impresses itself upon our memory organism, that by proper associative incitement, this order tends actually to be repeated. It is true that this same memory organism, lacking these major associative incitements, forms secondary associations, and these tertiary, and so on almost to infinity ; and in proportion to the frequency in which these minor associations occur, and in proportion to their kinship to original occurrences, do they also tend to rise in association processes. These minor and less constant associations are the basis of imagination ; "imagination" is a word which we associate with these *inconstant* flights of association ; "reality," "actual," are words we associate with the main *constantly* reappearing stream of association. The fundamental difference between imagination and recognition lies in the fact that the iterative habit of our nervous organism is so susceptible to original *outer* influences and so accurate and persistent in repeating these, that they ever *do* remain a comparatively unbroken series in representation, while those series which happen not by any outward actual order of incitement, but by secondary associations of portions of those primary series, do *not* persist in like unbroken representation. If, by any chance, a new link can be fastened into the original or actual memory order with the same associative firmness and strength as an actual occurrence would have been, then such will actually appear to be recognized as actually having occurred and psychologically will be so "recognized." Liars who frequently, actively and consistently enough practice their imaginary associations, do eventually arrive at such psychological "recognitions ;" all of us at times suffer such hallucinatory remembrances, and actually believe we did so, or so, or that such and such happened, when, actually, they did not ; and the hallucinations of the insane and the hypnotic are

confirmative of our hypothesis. Imagination is inconstant memory; remembrance is constant memory. As we have said both these processes commonly go on without conscious recognition of the fact that we *are imagining* or *are recognizing*. When these last processes occur, simply the bodily act rises to the focus of apperception; and in apperceiving the "act of imagination," imaginative ideas, that is, inconstant memories are called up and flit before the mind; while in apperception of the "act of recognition," portions of the constant train of memory are called up to constitute the apperceptive association.

Let us summarize the foregoing: Our simple creature received series of like sensations, but he did not recognize them to be alike. So we, if incapable of memory, should experience often repeated sensations, but should never recognize them to be the same. Even, if endowed with memory, we should never recognize a constant actual series of life's events, did not life's events happen in a single definite order. Our actual remembrances are representations which *do* follow the actual order of original events. Our imaginations are representations which do *not* follow the original order. The validity of our imaginations and of our recognitions, depend alike and absolutely upon the degree of faithfulness with which the neural processes which produce them correspond to the neural processes which produced the original psychic events.

Briefly stated, the final result of this protracted investigation of the time problem is as follows:

The general consensus of past and of current opinion is that time perception must alone be accounted for within some peculiar simultaneous psychic state, and, according to most authors, by some peculiar and disparate form of consciousness, in addition to our stream of ordinary sensations and their representative images.

The conclusion which we offer is that the processes of our environment, of our bodily organism, and of the sensations and images which correspond thereto, are, in themselves, within the limits of the insoluble mystery of the existence of

any physical or psychical existence at all, a sufficient explanation of time-psychology, and that time perception cannot be explained by any single state or disparate sense, but can alone be accounted for as a *process*. The bearing of the experiments of Section III upon these conclusions, and of the conclusions upon the experiments is obvious. The author is conscious that neither the one nor the other exhausts the topic, and will be content if they draw closer attention and study to the *habit relations* between neural and psychic PROCESSES.

Approved as a Thesis for the Degree of Doctor of Philosophy in Psychology at Clark University.

G. STANLEY HALL.

Worcester, Mass.,
Friday, May 1st, 1891.

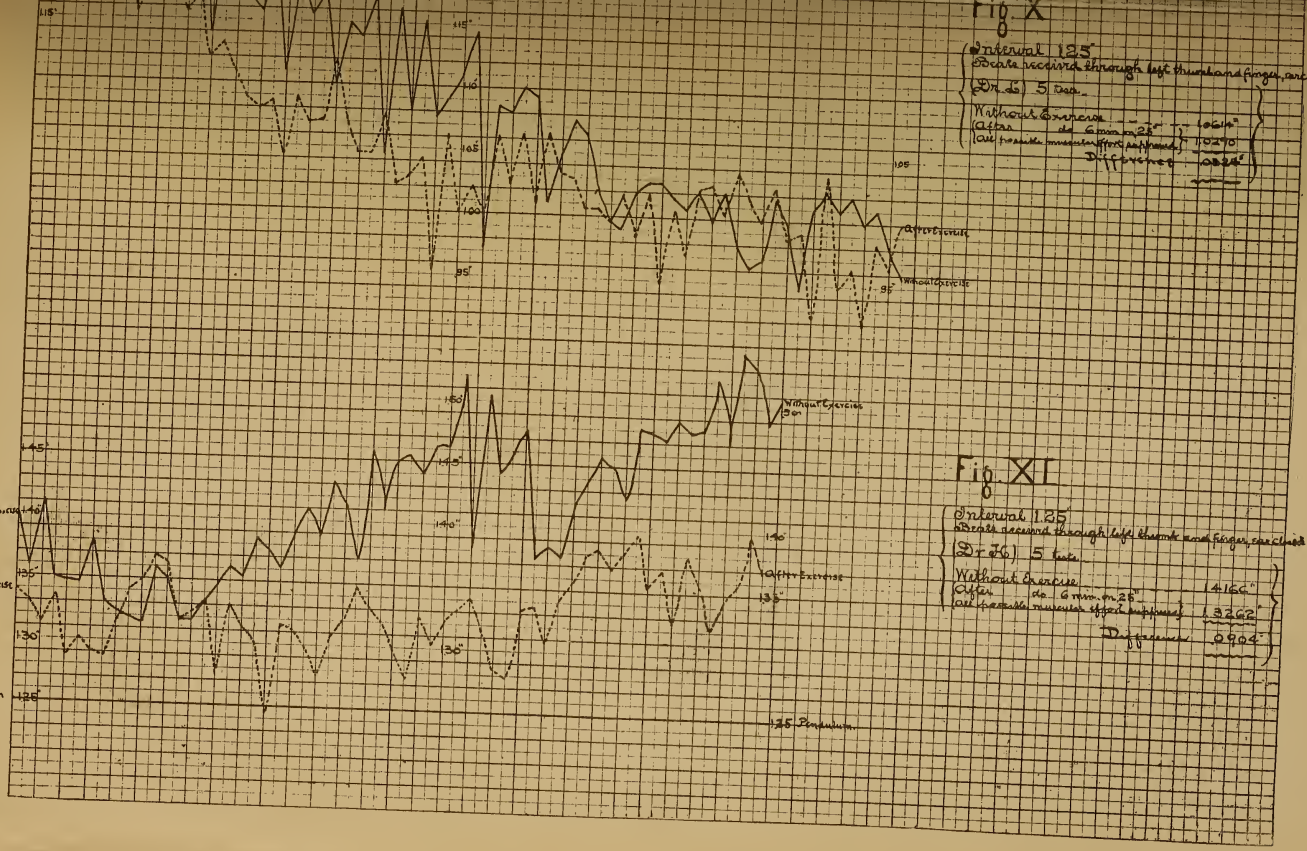

Fig X

Interval 125
Scale received through left thumb and finger, partclosed
Dr. de) 5 beats

Without Exercise	1.0616"
After do 6 min. on 25"	1.0290"
(all possible muscular effort suppressed)	
Difference	.0326"

Fig XI

Interval 125
Scale received through left thumb and finger, partclosed
(Dr. de) 5 beats

Without Exercise	1.416"
After do 6 min. on 25"	1.3262"
(all possible muscular effort suppressed)	
Difference	.0904"

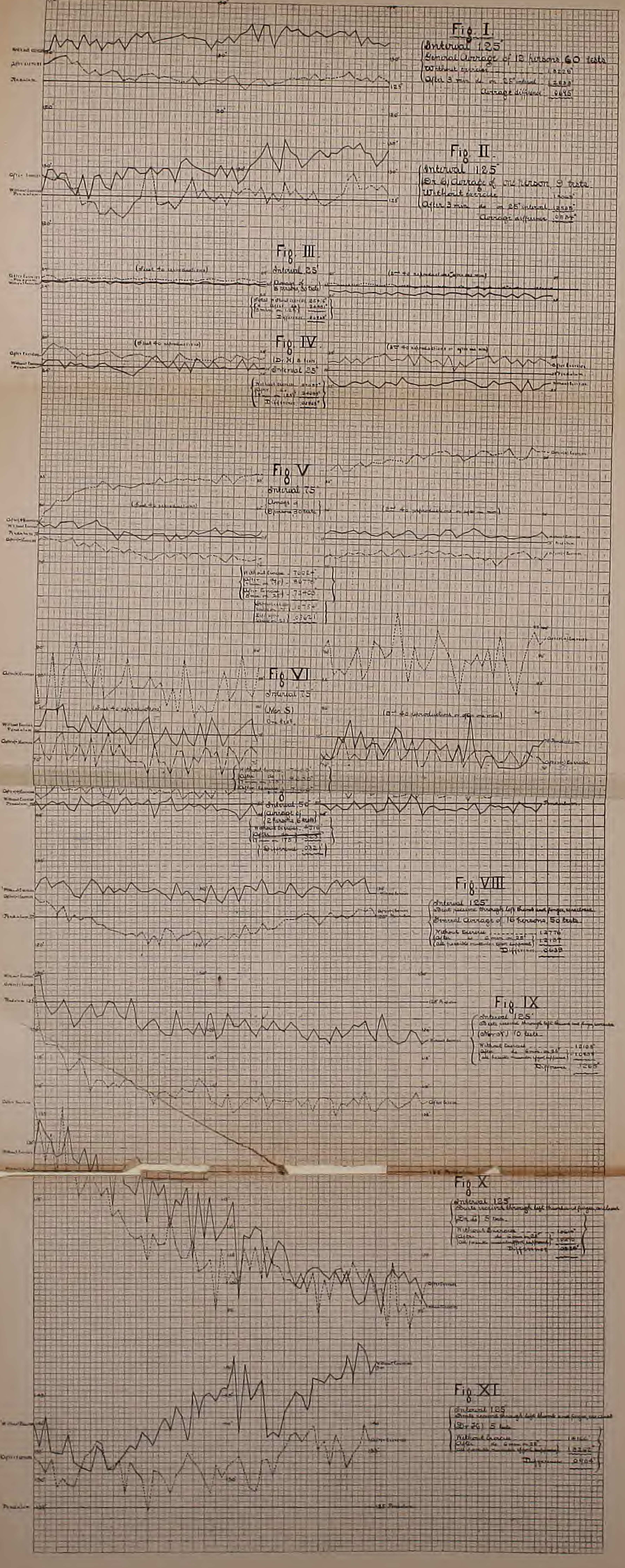

Fig. I.
Interval 1.25"
General Average of 12 persons 60 tests
Without exercise
After 3 min do on .25" interval
Average difference .0695"
Fig. II.
Interval 1.25"
(Dr G) Average of one person 9 tests
Without exercise
After 3 min do on .25" interval
Average difference .0534"
Fig. III.
Interval .25"
(First 40 reproductions)
Fig. IV.
(Dr. H) 8 tests
Interval .25"
(First 40 reproductions)
Difference
Fig V
Interval .75"
(First 40 reproductions)
Without Exercise .76024"
Fig VI
Interval .75"
(Mr S)
One test
(First 40 reproductions)
(2nd 40 reproductions or after one min)
Interval .50"
Difference .032"
Fig. VIII
Interval 1.25"
General Average of 16 persons, 50 tests
Without Exercise 1.2776"
Difference .0639
Fig IX
Interval 1.25"
(Mr S) 10 tests
Without Exercise 1.2105"
Difference .1265"
Fig X
Interval 1.25"
(Dr G) 5 tests
Without Exercise
Difference
Fig XI
Interval 1.25
(Dr G) 5 tests
Without Exercise
Difference .0904

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